THE

Tea Research Institute

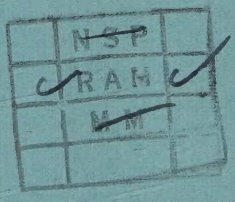
OF

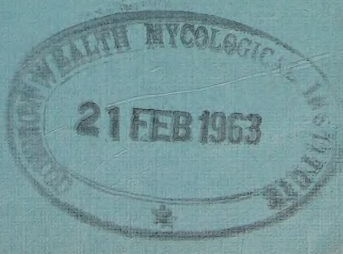
Ceylon

Annual Report for the Year

1961

Published by
THE TEA RESEARCH INSTITUTE OF CEYLON
ST. COOMBS, TALAWAKELE, CEYLON,
1962





The Tea Research Institute of Ceylon

Staff as at 31st December 1961

Director	D. L. Gunn, C.B.E., D.Sc. (Wales), Ph.D. (Birm)
Agricultural Chemistry	
Agricultural Chemist	J. A. H. Tolhurst, B.Sc. (Reading)
Research Officer	*Vacant*
Senior Technical Assistant	V. Mendis
Assistants	S. Samarasingham, T. C. Z. Jayman, E. O. Stuart, (Miss) B. I. Piyasena, B.Sc. (Cey.). S. Sundralingam. B.Sc. (Poona)
Biochemistry	
Biochemist	*Vacant*
Research Officer	M. S. Ramaswamy, B.Sc. (Mysore), A.R.I.C., A.I.I.Sc.
Assistants	T. S. Nathan, B. P. M. Perera K. Sivapalan, B.Sc. (Cey.), V. Fernando
Technology	
Technologist	E. L. Keegel
Research Officer	*D. Kirtisinghe, B.Sc. (Cey.)
Assistants	L. S. Weragoda, A. H. R. Balthazaar W. C. A. de Silva, B.Sc. (Cey.)
Plant Physiology	
Plant Physiologist	T. Visser, Dr, Ir (Wageningen)
Research Officer	U. Pethiyagoda, B.Sc. (Cey.), Ph.D.(Lond.), D.I.C.
Senior Technical Assistant	M. Piyasena
Assistants	S. Nagarajah, B.Sc. (Cey.) A. R. M. Hassim, N. S. Rajendram, B.Sc. (Madras) D. N. R. Wijewardene
Vegetative Propagation Officer	F. H. Kehl
Research Officer	S. Kulasegaram, B.Sc. (Cey.)
Assistants	H. R. Solomon, A. L. J. de Croos D. D. Kroon (Passara), H. B. Ratnayake (Hantane)
Plant Pathology	
Plant Pathologist	D. Mulder, Nat. Phil. Dr. (Amsterdam)
Research Officers	*N. Shanmuganathan, B.Sc. (Cey.) *R. L. de Silva, B.Sc. (Cey.)
Assistants	W. Redlich, B.Sc. (Cey.) P. V. Arulpragasam, B.Sc. (Madras) S. Murugiah, J. P. Herath, B.Sc. (Cey.)
Entomology	
Entomologist	J. E. Cranham, B.A. (Cantab.), D.I.C.
Entomologist, Special Research	E. Judenko, Ph.D. (Cracow)
Research Officers	*D. Calnaido, B.Sc. (Cey.) D. J. W. Ranaweera W. Danthanarayana, B.Sc. (Cey.)
Assistants	E. F. W. Fernando G. B. Rajapakse
Plant Breeding	
Post-graduate Scholar	A. R. Sebastiampillai, B.Sc. (Cey.)
Nematology	
Nematologist	M. T. Hutchinson, B.Sc., Ph.D. (Rutgers)
Research Officer	P. Sivapalan, B.Sc. (Cey.)
Assistants	M. K. Vythilingam P. A. John
Agronomy	
Chief Agronomist	H. N. Hasselo, Dr, Ir (Wageningen)
Research Officer	W. M. W. B. Manipura, B.Sc. (Cey.)
Statistics	
Statistician	P. Kanapathipillai, B.Sc. (Lond.)
Low-Country Service	
Scientific Adviser	A. W. R. Joachim, O.B.E., B.Sc., Ph.D. (Lond.), F.R.I.C., Dip. Agric. (Cantab.)
Assistants	U. L. M. de Silva J. I. H. Bandaranayake (Endane) K. H. G. Gunapala (Kottawa)

*Working overseas

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THIRTY-SIXTH ANNUAL REPORT OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON FOR THE YEAR 1961

Foundation.—The Tea Research Institute of Ceylon was established by Ordinance No. 12 of 1925 dated 27th October, 1925.

2. **The Constitution** of the Board of Control is laid down in the above Ordinance and in the following Tea Research (Amendment) Acts:

No. 24 of 1948 dated 20th December,	1948
No. 32 of 1951 dated 1st September,	1951
No. 51 of 1953 dated 19th December,	1953
No. 20 of 1955 dated 14th April,	1955
No. 8 of 1957 dated 18th March,	1957
No. 2 of 1959 dated 21st January,	1959
No. 3 of 1959 dated 21st January,	1959
No. 57 of 1961 dated 19th June,	1961

MEMBERSHIP OF BOARDS AND COMMITTEES

3. **The Board.**—The members of the Board on 1st January, 1961 were:—

CHAIRMAN : Mr F. Amarasuriya.

Ex-Officio Members

The Director of Agriculture (Mr A. V. Richards)
The Hon'ble Minister of Finance (represented by Mr H. E. Peries, O.B.E., C.C.S.)
The Chairman, Planters' Association of Ceylon (Mr H. Creighton).
The Chairman, Agency Section, Planters' Association of Ceylon (Mr L. F. J. Smith).
The Chairman, Low-country Products Association of Ceylon (Mr E. Muttukumaru).
The Tea Controller (Mr B. Mahadeva, C.C.S.)
The Director, Tea Research Institute of Ceylon (Dr D. L. Gunn, C.B.E.)

Representing the Planters' Association of Ceylon

Mr R. C. Scott, C.B.E.
Mr N. M. Sanders
Mr W. H. W. Coultas

Representing the Agency Section, Planters' Association of Ceylon

Mr R. D. Wedd
Mr R. J. Gilmour
Mr R. M. Macintyre

Representing the Low-country Products Association

Mr F. Amarasuriya
Mr M. P. Amarasuriya
Mr H. R. Fernando

Representing the Smallholders

Mr D. E. Hettiarachchi, J.P., U.M.
Senator Reginald Perera

Representative of the House of Representatives

Mr J. D. Weerasekera, M.P.

Secretary : Mr H. J. Balmond
Solicitors: Messrs Julius and Creasy
Auditors : Messrs Ford, Rhodes, Thornton & Co.
Registered Office : St. Coombs, Talawakele

The following changes in membership of the Board were recorded during the year :

Ex-officio members.—Mr A. R. Cathcart, elected Chairman of the Planters' Association to fill the vacancy created by the resignation of Mr H. Creighton with effect from 1st March.

Mr V. G. W. Ratnayake, M.B.E., elected Chairman of the Planters' Association for 1961 replaced Mr A. R. Cathcart with effect from 24th March.

Mr Francis Amarasuriya succeeded Mr E. Muttukumaru, J.P., as Chairman of the Low-country Products Association from 28th March.

Mr P. A. Silva, C.C.S., Acting Tea Controller, acted for Mr B. Mahadeva, C.C.S., from 13th May to 4th June.

Mr G. D. Loos, C.C.S., Assistant Controller of Supply and Cadre, was nominated to fill the vacancy created by the retirement of Mr H. E. Peries, C.C.S., with effect from 22nd July.

Mr W. W. Wood succeeded Mr L. F. J. Smith as Chairman, Agency Section, Planters' Association of Ceylon, as from 1st October.

Representatives of the Planters' Association of Ceylon.—Mr R. C. Scott, C.B.E., was renominated for the triennium commencing 17th December, 1960, but resigned from the Board from 7th December.

Mr N. M. Sanders was renominated for the triennium commencing 22nd February 1961.

Mr J. N. Atkinson acted for Mr N. M. Sanders from 12th July to 26th October.

Representatives of the Agency Section, Planters' Association of Ceylon.—Mr R. D. Wedd was renominated for the triennium commencing 1st January, 1961.

Mr R. J. Gilmour was renominated for the triennium commencing 23rd February, 1961.

Mr R. C. Bois acted for Mr R. J. Gilmour from 31st May to 28th September.

Mr R. M. Macintyre, C.B.E., resigned from the Board from 31st December.

Representatives of the Low-country Products Association.—Mr L. C. de Mel was nominated for the triennium commencing 3rd May, 1961, *vice* Mr F. Amarasuriya, who on election to the Chairmanship of the Low-country Products Association, became an *ex-offico* member of the Board.

Representatives of the Smallholders.—Mr D. E. Hettiarachchi, J.P., was renominated for the triennium commencing 29th October, 1961.

Mr C. S. Ratwatte, M. P., was nominated for the triennium commencing 29th October, *vice* Senator Reginald Perera.

Director.—Dr D. L. Gunn, C.B.E., Director, Tea Research Institute, was on annual leave from 19th June to 29th July. Dr A. W. R. Joachim, O.B.E., Low-country Adviser, acted as Director during this period.

Meetings.—There were five meetings of the Board during the year on 3rd March, 2nd June, 1st September, 1st December and 14th December.

4. **Administrative Committee**—The members of the Administrative Committee on 1st January, 1961 were :

The Chairman, T. R. I. (Mr F. Amarasuriya), Messrs B. Mahadeva, C.C.S., (Tea Controller), E. Muttukumaru, L. F. J. Smith, R. J. Gilmour, W. H. W. Coultas, R. M. Macintyre, and Dr D. L. Gunn, C.B.E., (Director, Tea Research Institute). Secretary—Mr H. J. Balmond.

The following changes in membership occurred during the year:

Mr R. C. Bois acted for Mr R. J. Gilmour from 31st May to 23rd September.

Mr V. G. W. Ratnayake, M.B.E., *vice* Mr E. Muttukumaru with effect from 2nd June.

Mr W. W. Wood *vice* Mr L. F. J. Smith from 1st October.

Dr A. W. R. Joachim, O.B.E., Acting Director, Tea Research Institute *vice* Dr D. L. Gunn, C.B.E., from 19th June to 29th July.

Meetings.—Five meetings of the Committee were held on 19th January, 21st April, 4th August, 10th November and 30th November.

5. **Experimental and Estate Committee.**—The members of the Experimental and Estate Committee on 1st January, 1961 were :

Chairman, the Director, T. R. I. (Dr D. L. Gunn, C.B.E.), Mr F. Amarasuriya (Chairman, T. R. I.), Mr R. D. Wedd, the Visiting Agent, St. Coombs Estate (Mr Alexander Mackie), the Chairman, Planters' Association of Ceylon (Mr H. Creighton), the Visiting Agent, Low-country Estate (Mr R. J. S. Bean), the Superintendent, St. Coombs Estate (Mr A. L. Elias), Messrs R. C. Scott, C.B.E., D. E. Heettiarachchi, A. E. A. Wallace-Tarry, S. P. Vytilingam, R. L. Harvey, C. R. Burnett, A. Watt, W. H. W. Coultas, E. N. Whitfield, P. S. Gray, A. J. Pelly-Fry and the senior scientists of the Institute.

The following changes in membership occurred during the year :

Mr A. R. Cathcart, Chairman, Planters' Association of Ceylon *vice* Mr H. Creighton from 1st March.

Mr V. G. W. Ratnayake, M.B.E., Chairman, Planters' Association of Ceylon *vice* Mr A. R. Cathcart from 24th March.

Mr A. I. Cameron *vice* Mr A. E. A. Wallace-Tarry from 1st March.

Mr R. C. H. Price *vice* Mr E. N. Whitfield from 1st March.

Mr P. S. Gray was on leave from 3rd July to 6th October.

Meetings.—The Committee met on 11th February, 6th May, 5th August and 14th October.

Appointments Committee.—The members of the Appointments Committee as at 1st January, 1961 were :

The Chairman, T. R. I. (Mr F. Amarasuriya), Mr B. Mahadeva, C.C.S., Mr A. V. Richards, Mr N. M. Sanders, Mr R. D. Wedd, Dr D. L. Gunn, C.B.E., (Director, T. R. I.), and Dr E. D. C. Baptiste (Director, Rubber Research Institute, co-opted for Senior Staff appointments). Mr H. J. Balmond (Secretary).

The following changes in membership occurred during the year:

Mr N. M. Sanders was on leave out of the Island from 12th July to 26th October.

Dr A. W. R. Joachim, O.B.E., Low-country Adviser and Mr R. J. Gilmour were co-opted to the Committee for special appointments.

Meetings.—Two meetings were held on 19th June and 13th December.

7. **Buildings Committee.**—The members of the Buildings Committee on 1st January, 1961 were:

Mr W. H. W. Coultas (Chairman), Mr F. Amarasuriya (Chairman, T. R. I.), Mr N. M. Sanders, Dr D. L. Gunn, C.B.E., (Director, T. R. I). Mr H. J. Balmond (Secretary).

Mr J. N. Atkinson acted for Mr N. M. Sanders during the latter's absence on leave out of the Island from 12th July to 26th October.

The Buildings Committee held nine meetings during the year.

8. **Low-country Sub-committee.**—The members of the Committee on 1st January, 1961 were:

The Chairman (Mr F. Amarasuriya), Messrs H. Creighton, D. E. Hettiarachchi, the Director (Dr D. L. Gunn, C.B.E.), Messrs R. J. S. Bean, A. Watt, J. L. D. Peiris (co-opted) and Errol Jayawickrema (co-opted) and Dr A. W. R. Joachim, O.B.E., (Convener).

The following changes in membership occurred during the year:

Mr M. P. Amarasuriya was nominated to the Committee *vice* Mr H. Creighton as from 1st March.

Meetings.—Four meetings of the Committee were held on 14th February, 16th February, 4th August and 4th October,

9. **Scientific Advisory Committee in the United Kingdom.**—The members of the Committee on 1st January, 1961 were:

Dr F. R. Tubbs, C.B.E., Director of East Malling Research Station (Chairman); Professor G. E. Blackman, F. R. S., Sibthorpian Professor of Rural Economy, Oxford; Mr F. C. Bawden, F.R.S., Director of Rothamsted Experimental Station; and Professor T. A. Bennet-Clark, F.R.S., Professor of Botany, King's College, London.

The Committee held two meetings on 5th July and 17th October.

Dr D. L. Gunn (Director) attended the meeting of the Committee held on 5th July.

10. **Trustees of the Tea Research Institute of Ceylon Junior Staff Provident Fund**:—The members of the Board of Trustees on 1st January, 1961 were:

The Chairman, T. R. I. (Mr F. Amarasuriya), the Director, T. R. I. (Dr D. L. Gunn, C.B.E.), Messrs R. J. Gilmour and D. E. Hettiarachchi, J.P., U.M. and Mr R. I. Pereira (Representative of the Junior Staff).

11. **Committee of Management, Tea Research Institute of Ceylon Junior Staff Medical Fund.**—The members of the Board of Trustees on 1st January, 1961 were :

The Chairman, T. R. I. (Mr F. Amarasuriya), the Director, T. R. I. (Dr D. L. Gunn, C.B.E.) and Mr W. P. Chandrasekera (representing the Junior Staff).

Mr P. N. Costa was elected as the Junior Staff's representative *vice* Mr W. P. Chandrasekera (resigned) with effect from 6th September.

12. **Other Committees.**—The following *ad hoc* Sub-committees continued during the year :

(a) The Provident Fund Sub-committee.—Appointed on 4th March, 1960 to examine and report on existing Provident Fund superannuation benefits to staff. The members of the Committee on 1st January 1961 were :

The Chairman (Mr F. Amarasuriya), Messrs L. F. J. Smith (Chairman, Agency Section), B. Mahadeva, C.C.S., R. D. Wedd, W. H. W. Coultas, R. J. Gilmour, H. E. Peries, O.B.E., C.C.S., (Deputy Secretary to the Treasury), Dr. D. L. Gunn, C.B.E. (Durector, T. R. I.) and Mr H. J. Balmond (Secretary).

Mr G. D. Loos succeeded Mr H. E. Peries (resigned) with effect from 22nd July.

Mr W. W. Wood succeeded Mr L. F. J. Smith from 1st October.

Two meetings were held during the year.

(b) The Economic Sub-committee on Instant Tea.—Appointed on 3rd June, 1960 to examine and take action on the economic and business issues arising from the development of Instant Tea as a commercial product. The members on 1st January 1961 were :

Mr F. Amarasuriya (Chairman), Mr R. J. Gilmour, Mr B. Mahadeva, C.C.S. (Tea Controller), Mr H. E. Peries, C.C.S., O.B.E. (Deputy Secretary to the Treasury), Mr V. L. Wirasinha, C.C.S., (Director of Commerce), Mr W. H. W. Coultas, Dr D. L. Gunn, C.B.E. (Director, T. R. I.) and Mr H. J. Balmond (Secretary).

Mr R. C. Bois acted for Mr R. J. Gilmour from 31st May to 28th September.

Mr G. D. Loos, C.C.S., replaced Mr H. E. Peries with effect from 22nd July.

Mr G. R. W. de Silva, C.C.S., replaced Mr V. L. Wirasinha from 15th March.

Two meetings were held on 3rd March and 3rd August.

(c) Salaries Sub-committee.—Appointed on 2nd September, 1960, the members on 1st January, 1961 were :

The Chairman, T. R. I. (Mr F. Amarasuriya), Chairman, Agency Section (Mr L. F. J. Smith), Chairman, Low-country Products Association (Mr E. Muttukumaru), Messrs R. J. Gilmour, D. E. Hettiarachchi, Dr D. L. Gunn (Director, T. R. I.) and Mr H. J. Balmond (Secretary).

Mr L. C. de Mel replaced Mr E. Muttukumaru from 2nd June.

Mr W. W. Wood replaced Mr L. F. J. Smith with effect from 1st October.

Three meetings were held on 15th February, 24th August and 9th October.

13. **Visiting Agent.**—Mr Alexander Mackie continued as the Visiting Agent for St. Coombs Estate. He visited the estate on 24th April, 21st August and 11th December.

14. **Finance.**—Income for the year which totalled Rs. 3,614,382 exceeded that of the previous year by Rs. 992,728. Receipts from the cess exceeded the previous year's figures by Rs. 1,050,634. The revenue profit from St. Coombs estate was less by Rs. 46,585. Other sources of income, viz. interest Rs. 69,613; rent of caddy Rs. 2,290; sale of clonal cuttings Rs. 7,381; and miscellaneous receipts Rs. 370; replanting subsidy Rs. 10,000; totalled Rs. 89,654 as against Rs. 100,975 in 1960.

Revenue expenditure (excluding depreciation) amounted to Rs. 2,209,399 as compared with Rs. 2,277,989 in the previous year. Decreases in expenditure were chiefly of the following items; Senior Scientific Staff Rs. 22,946; laboratory Rs. 4,656; field and factory experiments Rs. 97,610; maintenance of buildings Rs. 13,697. Increases were recorded in the following items: administration Rs. 2,615; Intermediate Scientific Staff Rs. 13,241; Junior Scientific Staff Rs. 18,341; library and publications Rs. 5,842; travelling of staff Rs. 10,198; general services Rs. 27,734; miscellaneous Rs. 13,237. Capital Expenditure totalled Rs. 1,756,207 as compared with Rs. 1,259,890, the main heads of expenditure being buildings Rs. 634,262; land and development Rs. 251,988; furniture and equipment Rs. 65,205; laboratory equipment Rs. 31,926; experimental machinery Rs. 6,400; vehicles Rs. 52,665; V. P. expansion Rs. 93,171; St. Joachim Estate Rs. 618,250. Accumulated depreciation as at 31st December 1961 was Rs. 2,358,113 with liquid assets amounting to Rs. 3,403,175 and liabilities to Rs. 1,067,332. The committed expenditure on new projects, i.e. buildings and water supply as at 31st December 1961 was Rs. 1,130,598/-.

Acknowledgments.—The Board records its thanks to the Ceylon Association in London, the Planters' Association of Ceylon, the Agency Section of the Planters' Association of Ceylon, the Low-country Products Association and other institutions for their continued support and co-operation in matters concerning the Institute and the tea industry in Ceylon.

The Board also extends its thanks to the Planters' Association of Ceylon and Messrs George Steuart & Co., Ltd., for having placed their meeting rooms at its disposal.

Auditors.—Messrs Ford, Rhodes, Thornton & Co., continued to act as the Institute's Auditors. The Audited Statement of Accounts and the Balance Sheet for the year ending 31st December 1961 are attached to this report.

H. J. BALMOND
Secretary

TEA RESEARCH INSTITUTE OF CEYLON

BALANCE SHEET AS AT 31ST DECEMBER 1961

1960 Rs.		Rs.	1961 Rs.	1960 Rs.		Rs.	Rs.	1961 Rs.
	ACCUMULATED FUND				FIXED ASSETS			
	Balance at 31st December, 1960	7,621,505			Cost per last balance sheet	7,043,937		
	Less: Adjustment in respect of previous year	9,934			Additions during the year	1,756,207		
		7,611,571				8,800,144		
	Add Excess of Income over Expenditure ..	1,100,794			*Less*: Transfers during the year at cost	65,507		
7,621,505			8,712,365	7,043,937			8,734,637	
709,630	CREDITORS AND PROVISIONS ..		398,684		Depreciation to 31.12.60	2,053,925		
76,888	PROVISION FOR FURLOUGH PASSAGES		68,649	2,053,925	Depreciation written off during the year	304,188	2,358,113	
	LOW COUNTRY SUB-STATION ..							6,376,524
	Government Loan		600,000	4,990,012				
				897,288	CEYLON GOVERNMENT AND U.K. GOVERNMENT SECURITIES AT MARKET VALUE			891,058
					CURRENT ASSETS			
					Stocks			
					Tea at estimated prices realisable	95,915		
					General and Electrical Stocks	48,213		
					Estate Sundry Stocks	6,004		
							150,132	
					Debtors and other debit balances		817,622	
					Debtors—Staff		81,098	
					Deposits		14,350	
				2,570,693	Cash in hand and balance at Banks		1,448,714	
								2,512,116
8,457,993			9,779,698	8,457,993			Rs.	9,779,698

We have examined the above balance sheet with the books of the Tea Research Institute of Ceylon and St. Coombs Estate and have obtained all the information and explanations we have required. In our opinion the foregoing balance sheet is properly drawn up so as to exhibit a true and correct view of the financial affairs of the Institute as at 31st December 1961 according to the best of our information and the explanations given to us and as shown by the books.

Colombo, 1st June, 1962.

Signed FORD, RHODES, THORNTON & CO.
Chartered Accountants

TEA RESEARCH INSTITUTE OF CEYLON

ESTATE WORKING ACCOUNT FOR THE YEAR ENDED 31ST DECEMBER 1961

1960 Rs.	Rs.		Rs.	1961 Rs.	1960 Rs.				Rs.	1961 Rs.
		ESTATE EXPENDITURE				TEA SALES—GROSS PROCEEDS				
	125,983	General Charges	125,763			Colombo	277,205	lb.	767,192	
	70,022	Upkeep	60,974			Local—B.O.P.	3,073	,,	6,305	
	53,993	Cultivation	43,933			Local B.M.	12,290	,,	10,146	
	113,026	Harvesting	112,102			Biochemical Dept B.O.P.	302	,,	686	
	116,134	Manufacture	113,583			Gratis ..	3,326	,,	—	
479,158				456,355						
13,236	Colombo brokerage & handling charges			11,938	866,512		296,196			784,329
132,154	Ad Valorem Tax			127,505	24,952	Sale of clonal cuttings				31,796
133	Debit Tax—on sales tax ..			129						
266,783	Balance to Income & Expenditure Account			220,198						
891,464			Rs.	816,125	891,464				Rs.	816,125

TEA RESEARCH INSTITUTE OF CEYLON

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31ST DECEMBER 1961

Rs.		Rs.	Rs.		Rs.
273,843	Administration	263,551	266,783	Balance from Estate Working Account	220,198
436,977	Senior Scientific Staff	423,781	2,253,896	Tea Cess	3,304,530
65,161	Laboratory	60,505	79,482	Interest	69,613
86,646	Intermediate Scientific Staff	99,887	1,800	Rent of Caddays ..	2,290
227,066	Junior Scientific Staff & Manor Employees	247,970	2,085	Miscellaneous Receipts	370
19,026	Library & Publications	24,868	7,272	Profit on sales of fixed assets	
318,369	Field & Factory Experiments	220,759	10,336	Clonal Cuttings Account	7,382
114,767	Travelling of Staff ..	125,328		Replanting Subsidy	10,000
46,509	Engineering Department	44,245			
78,384	Maintenance of Buildings	61,687			
182,064	General Service	209,798			
54,442	Miscellaneous	67,792			
350,000	Small Holdings Advisory Service	350,000			
267,688	Depreciation	304,189			
6,618	Depreciation on Investments	6,279			
6,609	Scholarship Expenses				
11,508	Low-country Substation, Napdt., St. Joachim				
75,977	Balance of Income over Expenditure	1,100,794			
2,621,654		Rs. 3,614,383	2,621,654		Rs. 3,614,383

TEA RESEARCH INSTITUTE OF CEYLON

SUMMARY OF FIXED ASSETS AND VEHICLES AS AT 31ST DECEMBER 1961

	ASSET ACCOUNT			DEPRECIATION ACCOUNT				
	Cost at 31.12.60	Additions in 1961	Sales Transfers scrapped 1961	Cost at 31.12.61	Accumulated at 31.12.60	For the yr.	Accumulated at 31.12.61	Written down value at 31.12.61
Land including development	1,572,050.92	251,987.54		1,824,038.46	159,462.90	31,963.71	191,426.61	1,632,641.85
Buildings and Lines	3,691,133.40	734,261.73		4,425,395.13	1,027,925.33	98,724.14	1,126,649.47	3,198,645.66
Furniture and equipment	629,787.15	65,204.69		694,991.84	235,191.10	32,301.01	267,492.11	397,499.73
Furniture Board of Survey	88,327.09	225.00		88,552.09	32,238.81	8,832.70	41,071.51	47,483.58
Laboratory Equipment	305,580.97	31,926.01		337,506.98	126,931.01	26,344.44	153,275.45	184,231.53
Experimental Machinery	80,252.31	699.85		80,952.16	77,086.37	3,025.23	80,111.60	1,540.56
Estate Machinery	209,739.37			209,739.37	199,362.24	10,377.13	209,739.37	—
Workshop Machinery	27,191.24			27,191.24	13,809.73	2,719.12	16,528.85	10,662.39
,, Equipment	29,143.39	1,351.78		30,495.17	9,703.04	2,944.33	12,647.37	17,847.80
,, Furniture	4,359.62	550.00		4,909.62	1,462.50	426.96	1,889.46	3,011.16
Vehicles Institute	156,540.06	52,664.85		209,204.91	66,751.79	20,687.60	107,439.39	101,765.52
,, Workshop	63,999.91	214.00		64,213.91	40,655.40	932.87	41,588.27	22,625.64
Library Shelving	2,391.78	—		2,391.78	956.68	239.17	1,195.85	1,195.93
Spectrophotometer	21,230.05	—		21,230.05	7,309.94	2,123.00	9,432.94	11,797.11
Leaf Hoist	2,055.38	—		2,055.38	2,055.38	—	2,055.38	—
Lawn Mowers	767.78	—		767.78	767.78	—	767.78	—
Monkey Grubber	2,534.77	—		2,534.77	2,534.77	—	2,534.77	—
Dusters and Sprayers	20,923.68			20,923.68	14,685.44	2,092.36	16,689.80	4,225.88
Leaf Elevator	10,708.55			10,708.55	9,425.10	870.85	10,295.95	3,212.60
Winnet Stone Crusher	15,733.80			15,733.80	15,733.80		15,733.80	—
V. P. Expansion	44,048.85	93,171.37		137,220.22	12,958.84	4,404.88	17,363.72	119,856.50
Buildings in progress	65,80[illegible]	[illegible]		[illegible]				618,250.00
Low-country Sub-Depot - Kithahengama		[illegible]		[illegible]				
	Rs. 7,043,937.33	[illegible]	[illegible]	[illegible]	Rs. 2,083,924.95	264,188.80	2,358,[illegible]	376,523.44

REPORT OF THE DIRECTOR FOR 1961

D. L. Gunn, C.B.E., D.Sc.

Staff.—The year was a good one for recruitment of senior staff. Dr H. N. Hasselo arrived from the Cameroons in June to set up the new department of Agronomy. Mr P. Kanapathipillai was seconded in October from the Department of Census and Statistics, where he had been working on agricultural statistics, to set up the new department of T. R. I. in that subject.

Dr U. Pethiyagoda from the Botany Department of the University joined our department of Plant Physiology on 1st December and work was begun on tea breeding by a postgraduate scholar, Mr A. R. Sebastiampillai, under the direction of Professor M. F. Chandraratna. Altogether six men were taken into the Intermediate Grade, including one promotion and four honours graduates in Agriculture and, since we lost one man in this grade, the nett gain was five.

During the year, no additional potential Ph.D. men began their training under the overseas scheme begun by Dr Joachim, but Messrs N. Shanmuganathan (Pathology), D. Calnaido (Entomology), D. Kirtisinghe (Technology) and R. L. de Silva (Pathology) continued their work overseas. Two of them are expected to return and take up work at T. R. I. again in 1962. Mr J. V. Sabanayagam returned from Ontario Agricultural College, Canada, with a B. S. A. (Tor.) degree, and Mr L. M. de W. Tillekeratne continued his work at Davis, California. More men are due to go overseas in 1962.

Losses of staff included Dr E. Judenko, whose work on Shot-hole Borer had twice been extended since his arrival in 1955, and his assistants. Thanks are due to Messrs Fisons Pest Control for seconding Dr Judenko to the Institute to tide over a difficult period; considerable progress was made as a result. Four members of the junior staff resigned and three of them were replaced, while nine other vacancies were filled. The results of all these changes were that the scientific staff in the Senior and Intermediate Grades increased from 18 to 24 and in the Junior Grade from 32 to 36; in these three grades, 32 were graduates.

The severe shortage of highly qualified chemists continued and seriously impeded progress on improving quality in tea.

Buildings.—The T. R. I. was originally organized on a simple system: there were four scientific departments (Mycology, Entomology, Biochemistry (Tea Technology) and, slightly later, Agricultural Chemistry), each headed by a senior officer who was later assisted by junior officers and minor staff. The juniors and minor staff carried out the instructions of the seniors, doing the routine work and supervising labourers in the field experiments. In each department, all the scientific knowledge and originality were provided by the single senior officer. By 1939, there was a department of Plant Physiology and a senior officer studying Phloem Necrosis, making 6 seniors; there were also 15 juniors, making a departmental scientific staff of 21. This worked well when the senior officers remained in the Institute for a reasonable number of years.

During the war, several senior officers were away and the normal work of the Institute had to give way to special needs of the war. By late 1948 three of them had left and the departmental senior staff was 4 with 14 juniors. Up

to this time, senior officers had tended to stay a long time. Of the 9 seniors who had been recruited up to 1948, before the last of them left in 1955, one had served 23 years with the Institute, and the average was over 13 years.

Then the situation changed. By 1951 only one of the old long-service staff remained. Of the seniors recruited after 1948, 5 had averaged under 6 years service before they left and the 7 that remained in 1962 had then averaged 4 years, with a maximum of 9 years. From Dr Norris's retirement in 1950 to October 1959, four men occupied the Director's place. It had become quite evident that reasonable continuity of work could not be expected from the old type of organization in the post-war conditions.

At the same time, the scope of the work had to be changed. Although Blister Blight had been contained, problems such as those of Shot-hole Borer and Eelworm had not been solved; the long-term fertilizer trials had suffered from changing control and they were soon to be made out of date by the advance of the industry; and new types of problems would have to be tackled if the industry was to be properly assisted. Further, the expansion of knowledge led to a very great increase in visits to estates, using much time and transport.

A strong feeling had developed that the research work ought to come under the charge of Ceylonese nationals. Accordingly, it was necessary to devise a scheme that would provide for the new situation, with non-Ceylonese senior officers for the time being, possibly frequently changing, and more permanent high-quality Ceylonese senior officers as soon as possible. The Mahadeva Reports of 1956 and 1957-8 concluded that the Institute was seriously understaffed and that a new grade of Intermediate Staff was required.

Specilization has been increased by adding departments of Technology (separate from Biochemistry), Entomology (once more separate from Pathology), a temporary group on the entomology of Shot-hole Borer, Nematology (separate from Pathology), Statistics and Agronomy (separate from Agricultural Chemistry), an Advisory Service to reduce the interference with research, and a Low-country Service to set up a large sub-station; and work was begun on breeding tea. The conception was that each senior officer would have at least one and preferably two Research Officers to help him, comparable to Scientific Officers in Britain, who could maintain continuity and from amongst whom heads of departments might be recruited in the future, after extensive training and experience. These additional scientists required additional junior staff.

By the end of 1961, there were 10 senior scientific departmental heads, plus vacancies in Biochemistry and the Development of Tea Manufacture, with 14 Research Officers, and 36 juniors. Six of the Ceylonese were over-seas receiving further training. The aim was to employ about 24 good Honours graduates initially in the Research Officer class, but with prospects for the outstanding men to enter the senior class. Backing up these scientists, the centralized administrative and maintenance services occupied another 27 men of the three upper grades. Some of these men were being housed on the old Passara sub-station on Gonakelle Estate and on the new sub-stations at Hantane (Kandy), Kottawa (Galle), and elsewhere; but the majority of them had to be housed at Headquarters on St. Coombs Estate and increasing numbers will be required at the new St. Joachim Estate in the low country. It is evident that, with a change in total in these grades from 22 men in 1939 to 60 in 1961, and more to come, a large building programme has been necessary, not only for their housing and amenities but also for their laboratories. The Mahadeva Report (1957-8) estimated the eventual housing additions as 14 Intermediate and 44 junior.

It is naturally required that this large increase in staff shall give a large increase in useful work. This has not yet shown itself fully because the earliest of the

new type of research officers does not return to Ceylon with his doctorate until 1962. There were at the end of 1961 four such men abroad and six in the two-year probationary stage before going overseas.

As a result of the two Mahadeva Reports, the staff has been steadily built up; but house-building is a slower process, so some houses have been overcrowded, some officers have had to live in rented houses inconveniently far from the Institute, and some officers have been occupying houses of a lower grade than their entitlement; and the build-up of staff has been impeded by lack of suitable houses. By the end of 1960, 1 large and 5 small senior houses, 4 intermediate houses, and 4 junior ones had been completed and occupied since 1956.

During 1961, under the vigorous leadership of Mr W. H. W. Coultas, further progress was made, though always too slowly for him and for the Institute. By the end of the year, the additional headquarters building at St. Coombs had been roofed and work was going on fast. This building is to house the new department of Development of Manufacture and to re-house Biochemistry as well as the Administration and the Library, thus allowing for expansion of the Advisory Division and providing accommodation for Agronomy in the old building.

In 1961, housing at St. Coombs continued to cause difficulties. The 17 junior staff houses at the western end of the estate were all begun but made excessively slow progress and not one of them was finished during the year. Two pairs of intermediate staff flats were begun and a very little was done towards a semi-detached pair of senior staff houses.

There was a very great improvement in the quality of the domestic water supply when the new filter system came into operation in September 1961 and this was greatly valued by the staff.

Outlying Stations.—A big step forward was made by the purchase of Kahahengama Division of Palmgarden Estate, near Ratnapura, for the new Low-country Sub-station. On December 1st, 1961, this became St. Joachim Estate, after the patron saint of Dr Joachim's family, to commemorate the energy and skill that he had devoted to the project. The estate covers 416 acres of which 300 acres were planted in tea.

Arrangements were made for the Saffragam Company to manage the estate at first, until houses could be built for estate staff. Houses were also required for the scientific staff before experimental work could begin. The large building programme for St. Joachim Estate, including the factory, offices, and houses, was being actively planned at the end of 1961.

A house was completed at the clonal testing station at Kottawa (Galle), for occupation by the officer in charge, and out-buildings were also provided. Houses for officers in charge and for advisory officers were also begun or planned for the clonal testing stations at Hantane (Kandy) and at Passara.

Finance.—After considerable delays that have been mentioned in the last two reports, as from 19th June 1961 the Tea Research Cess was raised from 55 cents to one rupee per 100 lb. of tea exported. Developments that had been slowed down were immediately accelerated again.

The estate with a profit of about Rs. 220,000 on revenue account, less Rs. 82,500 spent on capital account, yielded a contribution of Rs. 137,700 to the research aspects of the Institute. The Institute is not required to pay income tax. The effective acreage of tea was down to 215 acres compared with about 285 acres a decade ago. The reduction in this contribution is expected to

continue for several years, while the old tea is being replaced with mono-clonal vegetatively-propagated tea for experiments, as envisaged on pages 17-18 of the Annual Report for 1960.

Expenditure on experiments is down by about one lakh compared with 1960, but 1960 was an exceptionally expensive year in this respect, and there has been no restriction or reduction of experiments on financial grounds. There was also a slight and temporary reduction in costs of senior scientific staff, which was exceeded by a rise on other grades of scientific staff, a rise which is expected to continue and accelerate for a time as the staff is increased.

The reserves appear to be large, but they are not so when considered in relation to the capital expenditure on the factory, housing, and laboratory of St. Joachim Estate, expenditure which is being actively and carefully planned. On the whole, however, the Institute's financial position may be considered satisfactory.

Visits.—There were many visits by planters, other members of the Ceylon tea industry, government officials, scientists from Ceylon and overseas, and other distinguished persons. Such visits are of great value to the Institute, for they prevent any feeling of isolation and keep the members of the staff aware of important issues. Among the overseas visitors at the end of the year were two members of the Scientific Advisory Committee in the U.K., Professor T.A. Bennet-Clark, F.R.S., Professor of Botany in King's College, London, and a member of the Agricultural Research Council, and F. C. Bawden Esq., F.R.S., Director of Rothamsted Experimental Station.

Members of the staff visited tea research stations at Tocklai (Assam), Coonoor (S. India), and Kericho (Kenya), where they were very cordially received and enjoyed valuable discussions.

Instant Tea.—In 1960 the development of manufacture of a powder tea, direct from green leaf, reached the commercial stage. It had been found possible to get some of the desirable properties of Ceylon high-grown tea through into the powder, so that the product would probably be of a better class than any on the market and had every chance of success. After prolonged negotiations, in 1961 Government agreed to make certain concessions to assist the establishment of an instant tea industry in Ceylon, with the object of opening new markets for tea. The Economic Committee on Instant Tea selected Messrs Haelssen & Lyon of Hamburg to exploit these concessions. This company, in conjunction with Messrs Bosanquet & Skrine, has now registered CeyTea Limited in Colombo. The design and manufacture of the pilot plant has been pushed forward vigorously and it is expected to be erected in 1962. T. R. I. will help, if required, if any difficulties arise in conversion from the CISIR/TRI process to the pilot plant. When sufficient experience of manufacture and sale has been gained by CeyTea, it is expected that factories of larger capacity will be located in various parts of the Island.

Publications.—Publication of the Tea Quarterly and the Annual Report occurred as usual.

Research.—The reports of the research divisions speak for themselves. Perhaps the two outstanding features of the year were provisional recommendations for the control of Shot-hole Borer by dieldrin spraying and changes in fertilizer recommendations. Apart from a change in composition from the T500 series to the T700 series, there were preliminary indications of a radical change in the basis of use of fertilizers.

Trends.—In last year's report Ceylon's production in 1961 was forecast by extrapolation at 444 million pounds; the actual figure turned out to be 455 millions, the increase from 435 millions in 1960 being nearly twice the average

annual figure of 11 millions for the previous ten years. It is too soon to say whether the 1961 production was aberrant or whether it was the start of an accelerated rate of increase.

Production of tea in India has been rising at about 12 million pounds annually, and the world rate of production (not export) has been rising at about 45 millions annually, excluding U. S. S. R. and mainland China. There are indications that consumption is not rising fast enough to absorb these increases. At this point the Five-year Plan in India proposes to raise the rate of increase in that country from 12 to 40 millions per annum, giving an extra 200 millions in five years instead of 60 millions.

It is evident that we in Ceylon must be prepared for a fall in the prices obtained at auctions, a fall greater and more prolonged than that which occurred late in 1961 and a fall which might occur whatever we do in Ceylon. It seems unlikely that a revival of the International Tea Agreement would be possible, so as to limit world production; even if it could be revived effectively, the initial position has to be secured.

The function of the Tea Research Institute in this matter seems to be to help in every possible way to reduce the cost of production (COP) of tea and to increase its sale price, specially by reference to quality. The Institute has already done what it can on the other side, namely to open new markets with instant tea, but that will not have a large effect for some years.

The reduction of COP by reduction of the losses caused by pests and diseases has always been the concern of the Institute and a new step in this direction is made this year on Shot-hole Borer. But the big reductions in COP have been made and perhaps still can be made by increases in weight of crop per acre, and the resulting spreading of overheads more thinly. In spite of the fact that large increases in crop will tend to accentuate over-production, it is in such large increases that the main hope of reducing our COP may still lie. If serious reductions in auction prices do occur, the estates that reduce their COP most, by all methods, including increase of crop, will have the best chance of survival.

The most striking way of increasing yields per acre is to re-plant with selected clonal tea. In 1958, it was hoped to do this at 5,000 acres per annum, a rate at which older tea on the estates would have been replaced in under a century. By the end of 1961 it was clear, however, that the existing Tea Replanting Subsidy Scheme would not achieve any large fraction of this rate. Consequently it was proposed late in 1961 to increase the rate of subsidy and, more important, to make more liberal tax allowances for expansion of factories and living quarters; these changes may be implemented by 1963 but, since the tea takes time to grow, they cannot now help to reduce COP for several years.

There is reason to believe, however, that for a time it will still be biologically possible to increase production per acre in Ceylon, even without replanting. If it is correct to judge that the crisis of low prices is almost upon us, it is of little use to hope to meet it by plot trials or other approaches that will not begin to yield useful results for years. It is essential that such trials and other developments go on, and new ones are required and are being proceeded with as fast as possible; but they do not begin to deal with the situation that is probably impending. Something immediate is required. It seems to me that fertilizer dosage is the factor by means of which large and quick results could be achieved under the influence of suggestions from the Institute, and that no other single factor could be so effectively used. Accordingly, considerable attention has been paid to revising the ideas behind the advice given on fertiliser dosage (*see* pp. 59 and 115). Dr Joachim's article on page 133 of the Tea Quarterly for September 1961 also deals with the subject.

It may be thought to be unusual for the Institute to give publicity to—and to base an advisory policy on—ideas that have not first been fully worked out on tea in Ceylon and published. This is such an important question that some attention should be devoted to it. It would be very satisfactory if advice on a subject could be based on carefully designed experiments carried out repeatedly in various regions of the Island in such a way as to provide general rules and to indicate what exceptions there are to these rules. Unfortunately there are few, if any, subjects in which the scientific background is as clear and detailed as this, though the Institute is continually trying to extend this area of comparative certainty. A great deal of advice is, however, based on the general body of knowledge of agricultural principles, qualified by the personal experience of tea of the officer giving the advice and often by the result of experimental work at the Institute; such advice is frequently tendered in the form of suggestions for trial. Many of the suggestions tendered depend largely on the officer weighing up a complex set of circumstances, considered in discussion with the superintendent.

In the case of replacement and ratio manuring ideas, their use by an estate is likely to obscure the relationship of cause and effect and therefore to impede future analysis of the estate's data for the purpose of giving advice. However popular ratio manuring may have been in the past, every year's delay in abandoning it causes a year's delay in obtaining better estate data. This is one reason—and to me an over-riding one—for immediately asking estates not to use these ideas any more. The problem then is: what principles should be used and what advice be given instead? What is reasonably certain is that there is no single general rule that can compete with the replacement rule in simplicity—and the replacement rule is not valid. But the Institute will naturally make suggestions, in the years during which alternative methods of arriving at advice are being developed. A basis for such suggestions has been worked out and agreed between the officers concerned.

Whatever may be done by the industry in the way of accelerating the increase in production, it is evident that the present rate of increase is on many estates straining factory capacity. If yield increases accelerate, factory capacity may be so strained as to cause reductions in the value of the made tea, irrespective of market changes. Attention has therefore been devoted for some years to the problem of increasing factory capacity with a minimum of capital expenditure.

It is normal in industry to increase the capacity of a factory by double or treble shift working. The main impediment to this in tea manufacture by Ceylon methods is the time required to wither the leaf in such a way as to preserve its best properties, that is to say, without undue rise of temperature (over 90°F.). This time is so often more than twelve hours that it does not normally allow two shifts before the next day's leaf starts to come in. In fact it is often the withering capacity of a factory that limits its production of good tea.

Mr Keegel's investigations of open-meshed plastic for tats, in place of hessian, and the development of withering troughs seem to show the way to increased withering capacity without expensive additional buildings, but they do require additional expenditure. What is not perhaps generally realised is that the air circulation has to be correspondingly increased, for it is no good expecting to carry away double the amount of water vapour without doubling the air supply too.

The changes in technique that have been discussed are intended to be improvements on what is already being done on the best-managed estates. But there are many estates that are not so good and in which existing scientific knowledge and admittedly good management practices are not fully applied.

These are the estates which are likely to be in a poor financial position if bad times come; if these estates improved even up to present average, production and income would rise considerably.

It is particularly noticeable that auction prices for neighbouring estates often differ greatly. It is clear from Mr Keegel's advisory activities on factories that in many cases existing knowledge, as summarised in his Monograph, is not fully used. In many cases expenditure is required, sometimes relatively small expenditure, to modernize or add to equipment, but of course it is just the marginal estates, earning low prices, that can ill afford such expenditure. In other cases, all that is needed is proper use of existing knowledge, by taking a little trouble and at no expense. Mr Keegel's Monograph (No. 4 of 1958) on "Tea Manufacture in Ceylon" can help and his Division is attempting to improve the position by a series of one-day courses for teamakers in the districts; but the ultimate solution probably lies in recruiting as potential teamakers young men of a much higher educational standard, who can use the Monograph easily. In the mean time, these courses will doubtless help to spread knowledge of modern ideas about tea manufacture.

Although it is widely recognized—though perhaps not sufficiently widely—that the tea industry in Ceylon is facing severe difficulties, the industry has surmounted great difficulties in the past and there is reason to believe that it is resilient enough to continue to do so.

STAFF CHANGES IN 1961

Appointments and Promotions

Senior Staff

Dr H. N. Hasselo—Chief Agronomist, from 9th June.

Mr P. Kanapathipillai—Statistician, from 14th October.

Intermediate Staff

Mr D. J. W. Ranaweera, promoted to Research Assistant to the Entomologist, from 1st January.

Mr D. T. Wettasinghe, Research Assistant to the Chief Advisory Officer, from 1st March.

Mr S. Kulasegaram, Research Assistant to the Plant Physiologist, from 1st May.

Mr A. R. Sebastiampillai, Post-graduate Scholar in Tea Breeding, from 2nd May.

Mr W. M. W. B. Manipura, Research Assistant to the Chief Agronomist, from 1st October.

Dr U. Pethiyagoda, Research Assistant to the Plant Physiologist, from 1st December.

Junior Staff

Mr S. K. P. Thambimuttu, Stenographer, from 1st January.

Mr J. P. Herat, Technical Assistant to the Plant Pathologist, from 15th February.

Mr V. Fernando, Technical Assistant to the Biochemist, from 1st March.

Miss B. Piyasena, Technical Assistant (Temporary) to the Agricultural Chemist, from 2nd March.

Mr W. C. A. de Silva, Technical Assistant to the Technologist, from 1st April.

Mr K. Sivapalan, Technical Assistant to the Biochemist, from 1st April.

Mr D. S. Jayasekera, Library Assistant, from 15th May.

Mr S. Sundralingam, Technical Assistant to the Agricultural Chemist, from 17th May.

Mr D. N. R. Wijewardene, Technical Assistant to the Plant Physiologist, from 10th June.

Mr N. D. Lewis, Stenographer, from 21st June.

Mr A. L. J. de Croos, Technical Assistant to the Vegetative Propagation Officer, from 1st August.

Mr M. H. W. Ariyaratne, Accounts Clerk, from 15th November.

Overseas Training

Mr M. K. Vythilingam, Technical Assistant to the Nematologist, returned from U. S. A. after training in Nematology work on 26th December 1960.

Mr J. V. Sabanayagam, Technical Assistant to the Chief Advisory Officer, who was in Canada on a Colombo Plan Scholarship, returned on 13th July.

Resignations and other Terminations

Mr K. L. D. Ameratunga, Research Assistant to the Plant Physiologist, on 31st March (Intermediate Staff).

Mr K. M. L. B. Fernando, Electrician, on 30th April (Junior Staff).

Mr V. A. Rangala, Library Assistant, on 30th April (Junior Staff).

Mr W. P. Chandrasekera, Accounts Clerk, on 15th August (Junior Staff).

Mr A. C. B. Pethiyagoda, Technical Assistant, on 31st August (Junior Staff).

Mr C. Shanmugam, Technical Assistant to the Entomologist (Special Research), on 15th September.

Mr S. Calnaido, Technical Assistant to the Entomologist (Special Research), on 15th September.

Dr E. Judenko, Entomologist (Special Research), on 15th November.

Transfers

Mr H. B. Ratnayake from Kottawa Sub-station, Galle, to Hantane Sub-station, Kandy, from 1st December.

Mr A. H. R. Balthazaar from the Agricultural Chemistry Division to Technology Division, from 1st April.

Mr U. L. M. de Silva from the Advisory Division to Low-Country Sub-station, Ratnapura, on 1st December.

REPORT OF THE SUPERINTENDENT OF ST. COOMBS ESTATE FOR 1961

A. L. Elias

Staff.—Except for the prolonged absence of the Head Teamaker through illness and the Head Clerk as the result of an accident, there were no changes during the year. The work of all members of the subordinate staff throughout the year was satisfactory.

Acreage as at 31st December, 1961.

	A.	R.	P.
Tea in full bearing	202	1	21.29
Tea under experiments (plucking only)	27	0	0.00
New Clearing Field No. 1			
1959 planting	7	1	17.12
1960 planting	2	0	1.00
Llan Thomas & 14B—1961 planting ..	8	1	0.00
Guatemala grass clearing ..	9	3	0.00
Areas under rehabilitation			
Field No. 2	8	1	0.00
Field No. 7	13	0	0.00
Field No. 8	16	2	0.00
Nurseries Nos. 1, 12, New V.P. Nursery	3	0	0.00
Fuel Clearings, etc.	25	3	12.00
Buildings, roads, gardens, etc. ..	52	2	14.00
Land suitable for planting ..	6	0	11.00
Land unsuitable for planting ..	38	0	0.59
Area reserved for clonal cuttings ..	4	0	0.00
	423	3	37.00

During the year tea was uprooted on 6½ acres in Field No. 7 and 8¼ acres in Field No. 2 for replanting purposes. After approximately 18 months rehabilitation under Guatemala grass, these areas will be planted in April-June 1963.

A re-survey of St. Coombs estate by Mr G. W. Ferdinands began on 14th November, 1961, and several changes in the acreage under the various headings are anticipated.

Weather.—(Estate Gauge)

	Rainfall inches	Wet Days	Sunshine hours
Registered in 1961 ..	86.56	206	1,382*
Registered in 1960 ..	106.48	250	1,686
Registered in 1959 ..	92.80	212	1,996
Registered in 1958 ..	80.08	229	1,842
Registered in 1957 ..	97.72	221	1,992
Decennial averages (1951—1960) ..	93.58	229	1,835

(* January—no record was maintained and February maintained for 19 days only).

Rainfall was fairly well distributed throughout the year and no serious drought was experienced. Rainfall recorded during the first four months was 19.68″—46 wet days, i.e. January 2.52″—9 wet days; February 3.77″—10 wet days; March 4.55″—9 wet days; April 8.84″—18 wet days. The decennial average for the same period, i.e. January-April was 19.27″—55 wet days. Unusual weather conditions prevailed in February; from the 14th to the 23rd—3.61″ was recorded with a heavy afternoon fall of 1.46″ on the 17th.

Frost attack was first noticed on the 28th of the month and several pockets of tea in Fields Nos. 10, 14A and 14B were affected.

Strong winds from the south-west were much in evidence in May, June and August. Rainfall recorded in June was the lowest since 1935, but the 4.62″ which fell during the month was evenly distributed. Rainfall recorded during this period was May 16.18″—21 wet days; June 4.62″—18 wet days; July 8.35″—19 wet days; August 11.92″—29 wet days. September was a particularly mild month with only 4.46″—19 wet days. The early part o October up to and including the 18th of the month was mild. Thereafter heavy falls were recorded, namely 2.50″ on the 19th, 3.81″ on the 23rd and 2.89″ on the 30th. These showers were heavy and of short duration, falling in the early afternoon. Short dry spells were experienced in November and December and heavy mist was seen to settle in low-lying areas and hollows.

The total recorded rainfall for the year was 86.56″ which was 19.92″ less than in 1960 and 7.02″ less than the decennial average. There were 206 wet days, 44 fewer than in 1960 and 23 less than the decennial average.

Crop.—	1961 lb.	1960 lb.	1959 lb.
Estimate	255,000	270,000	270,000
Total crop (including off grades)	296,197	323,331	280,150
Yield per acre on 215½ acres ..	1,286	—	—
Yield per acre on 251½ acres ..	—	1,286	—
Yield per acre on 260½ acres ..	—	—	1,060

The estimated crop of 255,000 lb. of made tea was exceeded by 41,197 lb. and the yield per acre for the year was 1,286 lb. This figure is exactly the same as the yield per acre in 1960. Once again even monthly intake of crop was a feature throughout the year as follows:—

Month	Made Tea lb.	Yield per acre
January	25,450	108
February	18,176	78
March	22,853	97
April	35,139	147
May	27,851	117
June	31,254	134
July	22,129	94
August	19,555	81
September	17,827	79
October	23,091	103
November	24,710	115
December	28,162	133
	296,197	1,286

The highest monthly crop was harvested in April when the average yield for the estate was 147 lb. per acre. Cash plucking and Sunday plucking had to be resorted to on a few occasions. The quality of leaf brought into the factory was good throughout, and all teas fetched reasonably good prices.

Prices and Total Crop Sold.—

Year	Total crop sold lb.	Gross price cents	Nett price cents
1961	292,870	268	220
1960	320,521	270	225
1959	277,790	281	250

Prices fetched for St. Coombs teas at Colombo auctions (277,205 lb.), as distinct from those sold locally, were 277 cents (gross) and cents 226 (nett). These prices compared favourably with the high-grown average and with those of neighbouring estates. The nett sale average, however, has fallen below those of the two previous years. One of the reasons for this drop is the partial failure of the flavoury season in January-February this year.

The best invoices were :

Invoice No.	Month	Rs. per lb.
3	January	3.36
4	February	3.46
8	March	3.55

Cost of Production.—

	1961 Cost per lb. cents	1960 Cost per lb. cents	1959 Cost per lb. cents
Estimate	165	173	180
Actual	154	148	167

Profits on Estate Working.—

1961	..	Rs. 220,198
1960	..	,, 266,783
1959	..	,, 255,973

Capital Expenditure.—

1961	..	Rs. 82,528	28 cents per lb.
1960	..	Rs. 149,967	47 cents per lb.
1959	..	Rs. 140,823	50 cents per lb.

The main items of capital expenditure were :

	Rs.
Water supply to lines	4,851
Buildings	13,293
New Clearings	
1959 planting—7¼ acres	3,554
1960 planting—2 acres	390 (credit)
1961 planting—8¼ acres	21,715
1962 planting—15 acres	8,949
1963 planting—14¾ acres	20,723
Ravines to be cleared	4,211
Factory	2,879
Furniture	2,743

Plucking.—7-8 day plucking rounds were maintained throughout the year and the standard of leaf harvested was always of a fairly high quality. The plucking-incentive system of fixing a datum each day for each field has continued to work satisfactorily. The average per plucker for the year was 25 lb. compared with 27 lb. in 1960 and 25 lb. in 1959.

Estate Roads and Paths.—The usual routine maintenance of all field roads, footpaths and estate roads was carried out. Terracing of road side drains was done where necessary. A motorable field road through Field No. 4 was completed during the year.

Fuel Clearings.—Routine maintenance work was carried out during the year. The main drain leading out of the estate through Kowlahena estate, to the main river, was cleaned throughout its length and deepened wherever necessary. Boulders impeding the smooth flow of water were removed by blasting. All subsidiary drains flowing into the main leader drain were cleaned out. Supplies of firewood were adequate and the demands of all estate and institute Staff were met.

Boundaries and Ravines.—All boundaries are in good order and were regularly cleaned and maintained throughout the year. Regular rounds for removal of cootch and illuk were carried out. Many small ravines were reclaimed during the year and were planted up with mana grass.

Weeding.—The over-all cost of weeding for the year was Rs. 26,600.25 cts. or Rs. 9/54 per acre. Weeding contracts continued to be popular with labourers. A regular monthly round was maintained throughout the year with a minimum of scraping. The area weeded monthly on contract and the area weeded on estate account varied due to uprooting as follows :

Month	Total acreage weeded for the month	Contract acres	Estate acres
January	237¼	137¾	99½
February	237¼	135¾	101½
March	237¼	139¾	97½
April	237¼	200½	36¾
May	237¼	210½	26¾
June	237¼	204½	32¾
July	237¼	175	62¼
August	237¼	177	60¼
September	222½	173½	49
October	222½	175	47½
November	222½	170	52½
December	222½	173	49½
	2788	2072¼	715¾

All weeds were transported to a central compost shed and turned into compost by the Indore method. Weeds presented no problem during the year. Altogether 147 tons of compost were made during the year.

Pests and Diseases.—Blister Blight.—Spraying against Blister Blight continued periodically throughout the year whenever weather conditions became unfavourable and favoured this pest. No serious large-scale attacks were noticed. Localized attacks of some severity were apparent in small susceptible areas. These areas were demarcated and received special attention. Fields recovering from pruning continued to receive careful attention during the time of recovery from pruning.

Motorised knapsack mist-blowers were used throughout the year and proved to be extremely effective in tea for spraying copper fungicides for the control of Blister Blight. Four ounces of colloidal copper was used throughout in two gallons of water per acre.

Scarlet and Yellow Mites.—These mites were more in evidence this year. There was no large scale damage but spraying with *Karathane* was resorted to in Field No. 5.

Tortrix.—A good deal of Tortrix was seen in Field Nos. 4 and 5 and acting on the advice of the Entomologist, 50% D.D.T. wettable powder was sprayed in parts of these fields at 2 lb. per acre in 5 gal. of water by mist-blower.

White Grub.—No attacks of any severity came to light during the year.

Poria.—Poria patches in Field No. 3 received special attention during the year.

Pruning.—The following fields were pruned during the months indicated against each field :

No. 12—29½ acres—June
No. 3—34½ acres—September

In the case of Field No. 12 a light clean prune was adopted, taking out knotted and whippy branches. In Field No. 3, part of which is due for uprooting in 1962, 15 acres was given a light cut across and the balance of the field (19½ acres) was given a medium prune sufficient to carry on well into 1963. All pruning and tipping was done on the slope and recovery generally was good all over.

Supplying and Nurseries.—The nurseries in Field No. 1 and 12 continued to be used by the Nematology Division for experimental purposes.

The new V. P. nursery in the gum clearing adjoining Field No. 14A was used as the main nursery on St. Coombs and holds a little over 100,000 plants in polythene cylinders, comprising the following clones :

Clone	No.	No. of plants
DT	95	12,000
TRI	2024	27,800
TRI	2025	10,000
TRI	1114	5,000
TRI	777	5,000
TRI	2023	1,000
TRI	2026	1,000
DT	1	12,042
Red Marker Clone		22,000
Various clones		5,000
		100,842

The soil mixture used to fill the polythene cylinders was one part tea fluff to five parts of sub-soil by volume. The mixture should be broken down before use. At least four weeks must elapse before breaking down is complete. Manuring commenced six weeks after planting and very light applications at fortnightly intervals were given. The method of allocating the quantity of manure to be applied on each occasion per polythene cylinder was simply to ask the labourer to take a pinch of manure between his thumb and forefinger for each cylinder.

Woven coir matting (1/8" diameter holes) was used and watering carefully controlled at all times.

Mossing and Ferning.—Pruned fields were treated with "Limbux" to control moss and lichen @ 1½ cwt. per acre, using Birchmeir Senior Sprayers with No. 2 lime-washing jets. Ferns were removed by weeding contractors and this method was found to be successful. Moss, lichen and ferns are well under control. A fair proportion of all fern is removed by weeding contractors monthly and brought to the roads.

Manuring.—The practice of applying T. 500 mixture, altered from the T. 488 mixture at the beginning of 1960 was again changed in July 1961 when the T. 700 mixture was applied for the first time. It is necessary to record the history for future reference. The T. 488 mixture was applied either at 6-monthly intervals or when a field had yielded between 450 and 500 lb. of made tea per acre since the last application of manure, whichever was earlier. This method was altered at the beginning of 1960 and all fields received three applications of T. 500 mixture per annum, except in the year when a field was pruned. Fields, in the year they were pruned received two applications at the rate of 40 lb. nitrogen, one four months before pruning and one approximately four months after pruning. For the rest of the cycle, fields received further applications at intervals of four months on a growth basis of 10 lb. nitrogen for every 100 lb. of made tea harvested since the previous application. The application rate should never fall below 35 lb. of nitrogen, even though the amount of crop harvested in the previous four months may be less than justifies this figure.

All pruned fields received one deep forking in alternate rows during the first application of manure after pruning. Broadcasting was done at all other times.

The 1952 clonal area in Field No. 10 (2 acres) received two applications of T. 500 mixture at the rate of an average of 45 lb. of nitrogen per application and two applications of T. 700 mixture at the rate of an average of 45 lb. nitrogen per application. The 1954 clonal area (2⅔ acres) also received similar applications. Both these areas were manured on the basis of 1¼ oz. per plant per application.

The following field received one application of dolomite against magnesium deficiency :

Field No. 12—29½ acres

Top dressings of ground dolomitic limestone were given at an application rate of 400 lb. per acre.

Green Manure and Shade Trees.—Routine supplying and re-supplying of shade trees commenced in May and continued throughout the south-west monsoon period. Details of plants put out in all fields are as follows :

Grevillea robusta plants	*Albizzia moluccana* plants	*Albizzia sumatrana* plants	*Acacia pruinosa* plants	dadap stumps
3,016	2,205	1,710	1,997	854

The large *Albizzia moluccana* and *Albizzia sumatrana* trees in Field Nos. 9, 10, 12 and 13 were cut out gradually without undue damage to the tea. Low shade in the form of dadaps and *Acacia pruinosa* was lopped three times during the year and is well regulated throughout.

Cootch and Illuk.—Several patches of cootch grass and illuk in the mature tea areas received attention during the year and these pests are under control.

New Clearings.—The detailed position of field No. 1 is as follows :—

1953, 1954 and 1957 clonal planting.—In the 1953, 1954 and 1957 clonal planting, three of the larger blocks are reserved for experimental work or rested periodically for the sale of cuttings :

Block No.	Date of Planting	TRI Clone Number	A.	R.	P.
25	June 1957	777	0	2	37.81
41	October 1953	2024	0	3	6.13
60	June 1954	2025	1	0	29.75
			2	2	33.69

In these areas, as in all other clonal areas, a monthly weeding round was completed and spraying against Blister Blight carried out whenever necessary. Block No. 25 which was reserved for cuttings, was manured four times during the year, namely, in February and May using the T. 500 mixture with 24% magnesium sulphate @ 1¼ oz. per plant per application and in August and November using the T. 700 mixture at the same application rate, i.e. 1¼ oz. per plant per application.

Blocks 41 and 60 were also manured four times during the year, namely, February and June, using the T. 500 mixture and in September and November using the T. 700 mixture.

Shade trees were lopped and trimmed and all overgrown *Albizzia sumatrana* trees which had previously been ring-barked were removed. Hedges of *Acacia pruinosa* which were planted earlier as wind-breaks tended to become overgrown and thinning out or their complete removal will have to be given consideration after the dry months in 1962.

1955/56 Clonal Planting.—This area comprising A.6 R.0 P.27.60 was planted in June/July 1955 and June 1956. With the exception of block 46, a weak area, which has continued to receive special attention, all blocks in this area are in regular plucking.

1959 Clonal Planting.—This area comprising A.7. R.1 P.17.12 was planted in June 1959 with various TRI clones, namely 777, 2023, 2025 and 2026 and Kanapediwattie and Illuktenne seed. Blocks 10, 12 and 53 planted with seed are a long way behind the clonal blocks in respect of growth. It is significant that at this elevation (4,500 ft.) the clonal planting is at least six months ahead of the seedling tea. Cuttings were planted in nursery beds at the same time as the seed. The clonal blocks will be brought into revenue account in 1962.

1960 Clonal Planting—Blocks 8A & 8B—2 acres—Planted June 1960—Rehabilitation Period 3 years.—Following the complete failure of the small-scale planting distance experiments, this area received a set-back. Experimental blocks were handed back to the estate and large scale re-supplying had to be done to fill up vacancies created by deaths which followed immediately after planting. Shade trees and wind belts of *Acacia pruinosa* are growing well. Manuring was done five times during the year, namely in February, May, July, October and December, using Sterameal 'A' mixture @ 1 oz. per plant per application. In December the entire area was thatched with Guatemala grass loppings in preparation for the drought as this area is subject to rapid drying out.

1961 Clonal Planting

Llan Thomas area ..	..	A.3 R.2	P.37.70
14-B area ..	..	A.4 R.2	P. 7.25
		A.8 R.1	P. 4.95

To begin with a motorable road was cut through the 14B area and Field No. 14B leading towards the new cadday. The road passing over the Llan Thomas area was metalled and tarred. A survey of the two blocks was then undertaken. What was originally thought to be 10 acres turned out to be only 6½ acres. The Guatemala grass was cut down to ground level and experimental blocks were marked out by the Agricultural Chemistry Division. To ensure permanency of these blocks, angle iron posts were put into concrete.

Llan Thomas area, 3½ acres—There are 81 plots in this area. All plots were planted in May using one clone, namely, TRI 2024, at a planting density

of 6,000 bushes per acre. Fumigation of the entire area was carried out in March followed by holing a fortnight later. Inter-block spaces were also planted up with Clone TRI 2024. Altogether in 3½ acres 24,248 plants were put out but the area received two severe set-backs due to prolonged dry conditions immediately following planting and further resupplying was necessary. Shade used was dadap only and *Sesbania* was planted between silt pits. It was quite impracticable putting drains in areas covered with clonal blocks. The only alternative therefore was silt pits. These were put in wherever possible between experimental plots. In areas planted commercially, normal planting methods were adopted in both blocks.

At the time of planting, 1 oz. Sterameal 'A' was mixed with the soil in each planting hole in both areas. Vacancies caused by adverse weather conditions following planting amounted to 4,246 plants which were resupplied in June, 3,930 plants in July and 1,840 plants in August followed by a final resupplying in December of 1,320 plants. Further manuring with 1 oz. Sterameal 'A' per plant per application was carried out in July, September and December. A combination of bending and thumb-nail pruning was carried out regularly.

14*B area*, 4½ *acres*—There are 108 plots in this area. All plots were planted in August using two clones, namely, TRI 777 and TRI 2024 at planting densities of 4,000/6,000/8,000 bushes per acre. The delay in planting this block was due entirely to adverse weather conditions which prevailed in June/July.

Fumigation of the entire area was carried out in exactly the same manner as the Llan Thomas block and holing done a fortnight later. Inter-block spaces were planted up with 18,841 plants of Clone TRI 777. Altogether 28,841 plants were put out in this area in blocks as follows :

TRI Clone Number	Number of plants
777	18,841
2024	5,000
2025	5,000

Vacancies in this area were fewer. In August 2,248 plants of Clone TRI 2024 were resupplied. 2,815 plants in October and 1,120 plants of the same Clone in December were resupplied. Only 440 plants of Clone TRI 777 resupplied altogether during the same period. Manuring @ 1 oz. Sterameal 'A' per plant per application was done in September and December. Bending has been carried out over the whole area.

Areas under Rehabilitation for replanting. 1962 Replanting—15 acres (Field No. 7-6½ and Field No. 8-8½ acres).—Regular weeding was carried out and the Guatemala grass was lopped three times during the year at 20″ above ground level. Loppings were quite substantial. The area was manured three times, i.e. after each cut @ 4 cwt. per acre per application, the manure being broadcast immediately after the grass was lopped.

1963 Replanting—14¾ acres (Field No. 2-8¼ and Field No. 7-6½ acres.)—Uprooting by estate labour on contract began in August and was completed in October. As soon as weather permitted, contour hedges of Guatemala grass were planted at frequent intervals to minimise soil erosion. Heavy afternoon showers of rain which fell during October caused considerable gulley erosion in parts of both these fields. Leader drains with stone bunds were built in all gulleys, side drains on field roads were stone-bunded, and silt pits were cut. The ox-eye daisy was planted on all road banks. The Guatemala grass was planted 2′ × 2′ in October and was given the first fertiliser application in December @ 3 cwt. per acre.

1964 Replanting, 15 acres in Field No. 3—Slaughter plucking of this area commenced at the beginning of the year after it was known that this area was due to be uprooted in August 1962. As this area was 40 months from pruning, it was decided, after consultation with the Visiting Agent, to cut it across lightly. This was done in September. All high shade was removed and only essential field works are carried out. Regular manuring is done.

Factory and Machinery.—Complete renovation of the Marshall's Empire Drier stove was carried out by Messrs Walker, Sons & Co. Ltd. This has put an end to frequent collapses of the furnace brickwork which in turn upset the firing programme considerably.

During the year under review there were major breakdowns of rollers, particularly the No. 1 and No. 4 rollers. The No. 4 roller broke down in July and was given a complete overhaul. Defects in the No. 1 roller were attended to from time to time. This roller was fitted with an experimental table. All these interruptions interfered with the smooth working of the rolling room.

In February the rotary roll-breaker was fitted with stainless steel mesh Nos. 5 and 6. After some time it was noticed that owing to the fine gauge of wire used, uneven dhools were being obtained as a result of the mesh stretching. It is presumed that this can be rectified by fitting either No. 6 and No. 7 mesh or only No. 7 mesh. This will be experimented with in 1962.

The Woods Heat Exchanger unit installed some years ago by Messrs Brown & Co. Ltd., is lying idle.

Although a great deal of interest was shown in nylon mesh for withering tats, to take the place of jute hessian, it was not possible to obtain supplies of a suitable material for testing on a large scale. It is hoped that something in this field can be achieved in 1962.

The head storage tank (capacity 15,000 gallons) was emptied and cleaned out in March.

Manufacture.—Two types of manufacture were carried out during the year as follows :

January-September. . A 4-roll programme, i.e. 4 rolls of 30 min. duration (120 min. rolling). Four periods of roll-breaking of 10 min. duration (40 min. roll-breaking) with $2\frac{1}{2}$-$3\frac{1}{2}$ hrs. fermentation, charges every 50 min. Order—of firing 3, 2, 1, 4, Big Bulk.

October-December. . A 5-roll programme, i.e. 1st roll—40 min., 2nd roll—35 min., 3rd roll—30 min., 4th and 5th rolls—25 mins. duration (155 min. rolling), 5 periods of roll-breaking of 10 min. duration (50 min. roll-breaking). with $2\frac{3}{4}$-$4\frac{1}{4}$ hrs. fermentation, charges every 105 min. Order of firing 3,2,1,4,5, Big Bulk.

The percentage of dhools obtained on the various programmes were as follows :

	4-roll	5-roll
1st dhool	12	15
2nd dhool	20	17
3rd dhool	31	19
4th dhool	34	26
5th dhool	—	20
Big Bulk	2	2
	99%	99%

Grade Percentages.—

	1961	1960	1959
Broken Orange Pekoe ..	68.78	72.80	72.95
B. O. P. Fannings ..	8.14	8.07	8.28
Flowery Pekoe ..	2.25	2.98	3.01
Fannings ..	6.31	4.82	3.82
Broken Pekoe ..	2.52	.66	—
Broken Mixed ..	7.29	6.11	6.69
Orange Pekoe ..	—	—	.42
Dust ..	4.09	4.44	4.43
Experimental Teas ..	.62	.12	.40
	100.00%	100.00%	100.00%
Out-turn of made tea to green leaf ..	24.94%	23.91%	21.65%

Labour.—During the year children over the age of 14 years were registered. All incoming brides were also registered. Labourers were retired having reached the age of 55 years in the case of men and 50 years in the case of women. Health was generally good and except for mild epidemics of influenza, there were no large-scale outbreaks of any kind.

The labour force co-operated with the management throughout the year. Although there are now two Unions on the estate, namely, the Ceylon Workers' Congress and the Lanka Estate Workers' Union, this did not affect the smooth working of the estate. No Minute books were presented during the year and the management dealt orally with the spokesman of each Union on all problems affecting labourers.

A few letters were received from each Union but these were of little significance and generally the relationship between management and Union was satisfactory. There was a lightning token strike on Tuesday the 25th April. The annual sami-kumbudu was held during the week-ending 17th, 18th, 19th March.

	Men	Women	Children	Total
Working labourers on Estate as at 31/12/61 ..	249	240	2	491
Non working labourers (Pensioners)	26	19	—	45
Total estate population ..	285	264	529	1078

Working labourers numbered 1.63 per cultivated acre and the percentage of out-turn was 84%. One-fourth of all labour employed was used by the Institute for experimental work. In accordance with the Visiting Agent's recommendation contained in his report of the 27th April, 1960, the total working force will be restricted to 500. During the year one family consisting of one pensioner, three workers and two non-working children retired to India. Several families are interested in immediate repatriation but many obstacles are put in their way. Success is finally achieved after many visits to the Visa Office, Government of India, Kandy, filling in numerous forms and a great deal of correspondence both by the Superintendent and the interested party.

Buildings and Lines.—The total number of units, all up to Government standard, is 38 sets—217 rooms. The number of workers per room is 2.26 and the number of souls per room is 4.95.

During the year annual white-washing was carried out and all necessary minor repairs completed. A further set of lines, P. A. Health Scheme Plan

No. E/LQ/7(A) cottage type, were completed. Another cattle shed to accommodate six head of cattle was built. There are at present 62 head of cattle and 87 goats on the estate.

Once again the fly nuisance was fully controlled by sanitary methods and by regular spraying carried out under the personal supervision of Mr J. E. Cranham, Entomologist, and his staff, to whom a debt of gratitude and a vote of thanks is due for the able manner in which this potentially serious nuisance was controlled throughout the year.

All minor buildings on the estate are in a satisfactory condition.

Playground.—During the year, gradual filling up was done as and when earth became available. All slab rock, a lot of which was encountered in the middle of the ground, was removed. A concrete cricket practice pitch was built and members of the T. R. I. Sports Club cricket team are now able to practice as regularly as they want to in dry weather. The ground will be ready for use in January, 1962.

Visiting Agent.—Mr Alexander Mackie visited the estate on three occasions during the year on 24th April, 21st August and 11th December.

Clonal Blocks.—During the year the industry's needs of clonal cuttings was met as far as possible. Altogether 2,564,725 cuttings were sold to estates all over the island. In the case of estates in close proximity to St. Coombs estate, collection by lorry, van or car was made. A large number of cuttings, however, were despatched by rail packed in polythene bags and open crates. Two rounds of spraying with "Thiovit" (a sulphur preparation) were carried out against Yellow Mite attack.

Cart Roads.—All work on cart roads, hitherto undertaken by the Engineering Division, was carried out by estate labour during the year. Sign-boards were painted, guard stones, bridges and culverts received close attention, and all necessary repairs were carried out. Paths leading to bungalows were treated with Shellmac N. C. O. followed by a second coat of colas. The main road was surface painted with Mexphalte 80/100 hot bitumen wherever surface cracking was apparent. The bridge on the outlet road past the new cadday was completely rebuilt. A large retaining wall was built below the new Senior Staff Flats to protect the main road. The following new roads were completed:

Road to Intermediate Staff bungalow No. 3
Road to Superintendent's new bungalow
Road adjoining Senior Staff Flats
Road adjoining Power House
Circular road to Minor Staff Quarters
Llan Thomas road
Part of circular road past old cadday to T.R.I. Sports Club.

Factory Extension.—A building site to house the Withering Drum and Wilken's Withering Trough was cleared during the year at the Humidifier Chamber end of the factory. Tender specifications for this building were prepared by Messrs H. W. Hammond & Co., and tenders were called for through the medium of the press. It is hoped that work on this building will begin in the early part of 1962. The Sprinkler main pipe line was diverted in October.

General.—During the year the C. F. I. A's Inspector, Mr R. G. Harrison visited the factory for factory inspection and sprinkler installation surveys as follows:

13th February, 6th March, 11th April, 22nd May, 24th July, 30th August and 24th November.

The anti-T.B. campaign X-ray service visited the estate from 13th-16th March and all labourers and T. R. I. staff were X-rayed.

Fifty one dogs were vaccinated against rabies on the 9th August.

The Inspecting Medical Officer (Estates), Bandarawela, visited the estate on the 12th September and carried out an inspection of lines, dispensary, and maternity ward.

On the 13th March the Low-Country Products' Association organized a Field day at St. Coombs, which was well attended.

The year under review was altogether a satisfactory one. The crop harvested and the prices realized have been well above average and the profit obtained for the estate satisfactory in spite of unsettled and adverse market conditions in Colombo.

We now look forward to a good season in 1962.

METEOROLOGICAL OBSERVATIONS - 1961
ST. COOMBS
(Laboratory Gauges)

MONTH	TEMPERATURE °F						Mean Relative Humidity	RAINFALL		RAINY DAYS		SUNSHINE	
	Mean Maximum	Difference from Average (25 years)	Mean Minimum	Difference from Average (25 years)	Adopted Mean	Mean on Grass		Inches	Difference from Average (25 years)	Days	Difference from Average (25 years)	Hours	Difference from Average (25 years)
January ..	75·9	+ 1·8	54·8	— 0·9	65·4	50·7	76	2·02	— 1·58	5	— 6	168·6	— 24·1
February ..	71·2	— 4·9	54·1	— 0·5	62·6	52·6	78	3·25	+ 0·90	9	+ 1	77·7	— 133·3
March ..	76·1	— 1·6	54·7	— 0·8	65·4	53·6	73	4·00	— 0·54	8	— 4	217·6	— 15·4
April ..	74·1	— 3·3	59·0	+ 1·8	66·5	58·4	78	6·77	+ 0·40	13	— 3	179·6	— 16·9
May ..	70·1	— 2·3	59·6	— 0·1	64·9	56·9	89	15·54	+ 4·26	20	+ 2	127·4	— 36·6
June ..	71·0	+ 0·4	58·4	— 2·0	64·7	55·9	85	4·38	— 8·72	12	— 14	153·4	+ 61·4
July ..	70·4	+ 0·2	57·7	— 1·8	64·1	56·2	85	7·41	— 4·33	13	— 13	135·9	+ 30·7
August ..	68·6	— 2·4	60·1	+ 0·9	64·4	59·4	91	11·60	+ 2·18	23	— 2	74·7	— 39·4
September ..	71·5	— 0·7	57·6	— 0·6	64·6	57·4	89	4·13	— 4·24	13	— 8	108·8	— 31·5
October ..	71·5	— 1·6	57·6	— 0·1	64·6	56·2	90	9·65	— 0·04	19	— 3	150·3	+ 0·9
November ..	73·3	— 0·2	58·8	+ 1·7	66·1	57·9	91	3·82	— 3·60	15	— 4	149·8	— 11·7
December ..	73·5	0	56·8	+ 0·7	65·2	53·0	85	3·34	— 1·88	13	— 2	163·7	— 5·5
..	72·3	— 1·2	57·4	—0·14	64·9	55·7	84	75·91	— 17·19	163	— 56	1707·5	— 221·4
	Means							Totals					

REPORT OF THE CHIEF ADVISORY OFFICER FOR 1961

C. B. Foster-Barham, M.A.

Correspondence and Visits to Estates.—The total numbers of replies to enquiries, from all sources, rose in 1961 to 1,695, an increase of 190 over the figure (1505) for 1960. This rise appears to have been caused partly by the changes made in the Institute's recommendations for the manuring of tea and partly by the late appearance of the South West Monsoon, which occasioned a prolongation of the dry weather conditions during the earlier half of the year. Such dry weather conditions in general tend to accentuate the effects of factors detrimental to the health and vigour of the tea; such effects are not necessarily primarily caused by drought alone.

Enquiries were received from 460 estates. This figure represents 43% of the total number of those listed in the 1961 Ferguson's Directory and covers 88% of all tea districts. This is 3% increase in number of estates and 8% decrease in number of districts contrasted with 1960 figures.

Enquiries not received directly from estate sources numbered 330 and rose by 40 over the 1960 figure.

Additional staff enabled visits to be made to 101 estates in 26 different districts. This is 41 more estates than in 1960. Other Divisions of the Institute dealt with special enquiries and paid many visits which are not included in this summary.

Soil Samples.—The Institute discontinued routine analyses of soil samples for eelworm in November 1960, and these have been taken on by firms in Colombo (see Tea Quarterly 31: 116-118). Routine measurement of pH has continued, however, though on a much reduced scale because of the frequent necessity of reporting on both pH and eelworm together. The Advisory Division reported last year on 1223 pH samples. This year it was down to 437.

It still seems to be expected by some estates that the Institute will advise on manuring policy on the basis of analysis of soil samples for nutrients alone, or that the recommendations of firms regarding manuring policy and fertiliser mixtures based on this particular kind of soil analysis, which is carried out by these firms, can receive the Institute's comments. The inevitable reply we have to give to such enquiries is that this is not at present possible because of complicating factors which interfere with the relationship between chemical availability of soil nutrients and their uptake by the tea. These complicating factors are discussed by Mr Tolhurst in the Tea Quarterly (31: 98-100).

Plant Specimens Submitted for Diagnosis and Report.—A total of 774 cases of ill health and of death from various causes were recorded for 1961 amongst plant specimens sent to the Advisory Division for diagnosis, as classified under :—

(*a*) due to fungi 213 ;
(*b*) due to deficiency and toxicity of chemical elements 68 ;
(*c*) due to virus, bacteria, and unidentified causes 6;
(*d*) due to insect pests 248 ;
(*e*) due to nematodes 17 (cases of lesions in root tissues only);
(*f*) due to faulty soil-pH and texture, effects of weather and human factors 222.

(a) Fungi.—Amongst the more important causes due to fungal infection, *Poria* continued again this year to be the most common. It was reported from 15 districts, but the total number of reported cases for this year, 45, had declined from last year's figure 54. The reason for this may possibly be that the focusing of attention on *Poria* by estates on which the disease threatens to become of serious economic proportions has brought about more widespread ability to recognise *Poria* symptoms without referring to the Institute for identification.

Other than *Poria*, *Fomes noxius*, *Rosellinia arcuata* and *Ustulina deusta* (or *zonata*) continued to be most commonly reported. The number of cases of these three particular diseases reported for last year were 29 (in 12 districts); 24 (in 12 districts); and 35 (in 15 districts) respectively. Amongst these figures only that for *Ustulina* declined markedly this year from last year's figure (43). The explanation for this is not known.

The numbers of cases of other reported fungous diseases were well below the lowest of the above figures. Amongst unusually rare occurrences recorded were one case of *Rosellinia bunoides* (B and Br) Sacc. in Nuwara Eliya district, and one of *Poria hypolateritia* found at about 400 ft. above sea level in the Galle district. As far as past records show this appears to be the lowest elevation at which *Poria* has been recorded so far on tea in Ceylon. The characteristics of *Rosellinia bunoides* are similar to those of *Rosellinia arcuata*, except for the absence of a star-shaped mycelium.

(b) Deficiency and Toxicity of Chemical Elements.—Magnesium deficiency (25 reported cases) was again the most common deficiency this year, and this is also reflected in the number of enquiries received concerning magnesium fertilizer (45).

Potassium deficiency received notably increased attention this year, consequent upon the changes made in the composition of the Institute's recommended fertilizer mixtures; variations in proportions of potash were advised in the T. 700 series, mainly for differences in elevations of estates, while sulphate of ammonia and Saphosphosphate quantities remained fixed in proportion to each other in this series. The announcement was published in the Tea Quarterly for September (32: 148-151). Potash deficiency was reported in 16 cases only. It is possibly a remarkable psychological fact that only 3 cases of potash deficiency were brought to the Advisory Division's attention in 1960.

Nitrogen deficiency symptoms reported were remarkably few in number (3) this year as opposed to last year (14). Whether this is due to increased knowledge of the symptoms by estates, or to some other factor, cannot be explained.

Boron and zinc deficiencies were likewise subjects of increased attention this year. The Advisory Division received 4 boron cases and 7 zinc cases only. These deficiencies have received the primary attention of the Agricultural Chemist, who discusses them in his annual Report. It is too early yet for me to comment on their general distribution in the districts.

Manganese toxicity is at present the only case of excess element up take which has received much attention and whose leaf symptoms are now recognised to occur more commonly amongst Ceylon tea than hitherto suspected. There were 13 cases of this toxicity diagnosed by the Advisory Division this year as opposed to only 3 last year.

(c) Virus, Bacterial and Unknown Conditions.—The numbers reported were very few, and included the following :—

Galls and cankers	1
"Little leaf" condition	2
Oilspot disease	Nil
Phloem necrosis	3

(d) Insect and Acarine Pests.—The most commonly reported group appears to have been the mites, of which the most common was Red Spider Mite (31 cases). Generally drier weather conditions within the earlier half of this year, in the south-west zone in particular, appear to account for a considerable increase in the number of reported cases of this species over last year's figure. There does not appear to be much significant change for the other mite species.

The actual total number of reported cases for 1961 contrasted with those for 1960 were :—

	1960	No. of districts	1961	No. of districts
Red Spider Mite (*O. coffeae*)	11	7	31	20
Yellow Mite (*H. latus*)	21	13	23	15
Scarlet Mite (*Brevipalpus Spp.*)	16	10	13	7
Purple Mite (*C. carinatus*)	11	7	9	5
Total No. of mite cases	59	—	76	—
Total No. of districts involved	—	16	—	29

The shot-hole-borer problem, as is well known, is one of the most acute in tea in Ceylon. Provisional recommendations for control were published in December in the Tea Quarterly (32: 171-184).

Reports of Tea Tortrix (*Homona coffearia Nietn.*) were again fairly common. There were more outbreaks in the mid-country which followed an increasing use of dieldrin for shot-hole-borer control; these were generally well controlled with DDT, with the only drawback that DDT increased Red Spider Mite on a few estates, principally in the Pussellawa, Kandy, and Rakwana districts. Generally, this effect did not occur, but there is an obvious need for an alternative to DDT on those estates that suffer this effect.

Apart from outbreaks following dieldrin, there were, as in 1960, a high number of outbreaks of natural origin in many estates above 4000 ft, particularly in Dimbula, Dickoya, Maskeliya and Udapussellawa.

Figures, this year, as contrasted with last year, for Tortrix attacks reported through the Advisory Division were :—

Year	No. of Tortrix cases	No. of districts involved.
1960	17	9
1961	35	13

Amongst insect pests of lesser economic importance may be mentioned Lygus Bug (7 cases), Nettle Grub (4 cases), Red Borer (7 cases), scale insects of various species (15 cases), termites of various species (19 cases) and White Grub (12 cases).

(e) Nematodes.—Soil analysis for eelworm is done in Colombo instead of as formerly by the Institute, so data on soil samples are not compiled, except for those which are analysed for research purposes.

It may be said that as a result of survey carried out by the Nematology Division the heaviest infestations are to be found in the Dimbula and Maskeliya districts, and that the numbers found in soil samples indicate that the lower limit of potentially dangerous populations lies at about 3,000 ft. above sea level.

Most of the observations on eelworm infestations carried out in 1961 by the Advisory Division were deduced from estate visits and very few from the

examination of specimens received, only 17 cases of lesions in root tissue having been reported in such specimens altogether. The extent of meadow-eelworm infestation amongst mature tea on some estates in the Dimbula district in particular deserves certain comment in connection with the fact that in this district estates which have a serious meadow-eelworm problem also have a serious *Poria* problem and in some cases, to make things worse, also Shot-hole Borer. Double or treble complexes of this kind are not common in the Ceylon tea industry, but where they do occur they constitute a serious economic threat to the estate concerned, particularly if the complex has reached a critical stage which demands reconditioning and replanting.

(f) Faulty soil pH and texture.—The total number of estates during 1961 reporting failures in nurseries due to too high soil pH was 10 and those reporting failures associated with faulty soil texture 18.

It was possible to warn some 27 estates who submitted samples for analysis, not to use soil for planting for one or other of these two reasons. The ratio of those estates warned in time to those who suffered, for both conditions together was 32: 19 in 1960 and 27: 23 in 1961. The pH and texture problems in nurseries appear to have assumed greater importance in 1961 than in 1960.

(g) Faulty crop husbandry.—Within this class there have been included the following which may be said to be controllable by stricter supervision.

	Numbers of cases 1960	1961
1. Too close proximity of thatch to young bush collars in clearings, causing heat scorching or wet rot	18	4
2. Incorrect transplanting of rooted nursery plants into field planting holes, resulting in bent or or twisted roots.	6	7
3. Pegging down of young branches too close to the ground when layering or bending	1	1
4. Manurial scorch due to excessive or careless application	4	3
5. Planting too deeply, and also failing to keep soil clear from heaping up round collars of young plants in clearings.	14	25
6. Over-plucking (''Crow's feet'')	1	2
7. Too clayey texture of soil in nurseries, causing impeded drainage, and over-callousing of V. P. cuttings.	8	18
8. Over-watering or excessive dampness of soil in nurseries	15	25

General Enquiries.—The total number of questions asked on different subjects, which involved no examination of specimens came, for 1961, to 726; last year this was 586, a clear indication of increased use of services rendered by the Advisory Division. Amongst the more important subjects are listed:

(a) Manuring and fertiliser mixtures.—Due to the change-over in May to the T. 700 series of fertiliser mixtures, there was an almost immediate spate of enquiries on this subject alone, and the number of estates and other enquiries which had sought information about the new series by the 31st December was 90. The total figure for all questions on manuring and fertiliser mixtures, rose from 204 in 1960 to 238 in 1961. These figures exclude questions or advice about manuring which arise from the examination of plant specimens, either in the field or in the laboratory.

The commonest types of questions about manuring were those which required information about manuring and manuring technique in general (55), specific information about the manuring of young tea in nurseries, multiplication plots and clearings (11), about nitrogen ratio (9), potash application (12), policy in regard to yield levels (7), Institute approval of fertiliser mixtures other than those being currently recommended (10), composition of and percentage of N, P, K in fertiliser mixtures (6), dolomite and magnesium sulphate application (44), urea and its foliar application by spraying (11), soil analysis for nutrients and requests for advice based on this analysis (10), and compound granular fertilisers (7).

(b) Clones and V.P. technique.—Exclusive of advice given on plant and soil specimens examined, there were 94 replies given to questions on this subject. Within this class the following more important matters may be included :—

General information on all aspects of V. P. technique	27
Requests for supply of clones and information on sources of supply	15
Approval of new estate clones	13
Manuring of V. P. cuttings in nurseries	13
Suitable clones for specific districts	12
Resistant and tolerant clones	9

(c) Blister Blight and its control.—Some 40 enquiries covered this subject during the year (37 for 1960). These comprised 14 enquiries on general collective information; 11 on sunshine recording; and 15 on motorised power-spraying and dusting.

(d) Cultivation.—The total number of enquiries received on this subject numbered 8 (7 for 1960). These figures are unusually small in view of the importance of taking measures to prevent soil erosion, but they may be partly due to the fact that governmental anti-erosion measures have to be carried out before planting to be properly effective, and comparatively little acreage under replanting is involved. Most of the enquiries related in this case to views on the advisability of deep forking.

(e) Rehabilitation and replanting.—Altogether 17 enquiries were received on this subject, and the low figure appears to be a general reflexion on the economic position of the estates. In certain very special instances a few estates have sought, and succeeded in being granted, special permission to replant without reconditioning. Conditions under which the statutory obligation may be waived are very strictly defined, however, and special permission of this nature has been rare.

(f) Shade and Ground Covers.—There were 14 enquiries connected with shade trees and 19 on ground covers during the year. While shade remains a controversial matter, there has been no change in current recommendations on this, and the existing position is as detailed in the Tea Quarterly conference numbers for March and June 1961.

(g) Shot-hole Borer.—It is known that about 100 estates have carried out sprayings with dieldrin in 1961 on one field or more. Quite a few estates were doing it routinely as fields were pruned. There is some interest in every P. A. district since all districts have some tea between the elevations of 500 ft. to 4000 ft. which is attacked by Shot-hole Borer.

Over 200 leaflets on "The chemical control of Shot-hole Borer" (dated 24. 10. 60) were sent out on request to estates and agency houses. In December

provisional recommendations for the control of Shot-hole Borer and the Tortrix side-effect were published by the Entomologist in the Tea Quarterly.

(h) Requests for tea literature.—A very considerable rise in demand for literature on all aspects of tea planting in Ceylon occurred this year. The figure jumped from 21 in 1960 to 88 for this year. The Advisory Division has sent out Tea Quarterlies, reprints, photostats, monographs, and booklets, and copies of advisory leaflets. Also, with the introduction of a photography department attached to the division, batches of photographs at special requests. Some 34 of these requests came from estates, and appeared to be mostly connected with personnel taking examinations . A number of enquiries also came from Victoria in Australia. These may have been connected with essay competitions.

(i) Weeds and weed control.—A total of 25 enquiries on this subject were received (22 in 1960). The only weed-killer that is being suggested for use amongst mature tea at present is Simazine, at the manufacturers' recommended dosages. The effective depth of control in the soil of this compound is about four inches, with maximum effects for about the first two. It does not therefore control satisfactorily weeds with roots or rhizomes capable of regenerating growth from below this depth. Its low solubility in water and its persistence in about the first four inches is nevertheless a valuable preventative against the germination of most weed seeds situated within this shallow zone, or brought to the soil surface by prior cultivation.

Staff Matters.—The Chief Advisory Officer proceeded to the U. K. on overseas leave on 20th November, 1961, and returned on 20th February 1962. His place as Acting Chief Advisory Officer was taken by Mr J. A. H. Tolhurst.

Mr D. T. Wettasinghe was appointed to the Advisory Division as Research Assistant and took up his duties on 1st March 1961, from previous employment at the Technical Training Institute, Amparai.

Mr J. V. Sabanayagam returned from Ontario Agricultural College, Canada, with a 1st Class B.S.A. degree in Plant Pathology, and is to be congratulated.

Mr L. M. de Waas Tillekeratne is at Davis, California, where he has been studying Agricultural Education. His return to St. Coombs is expected early in 1962.

Mr L. Coonghe joined the Institute as Assistant Photographer to Mr D. J. M. Hettiarachchi on 17th April 1961.

Visitors.—Visits from numbers of groups of field officers, students and trainees were received from the following. There were approximately 250 visitors.

Department of Agriculture, Peradeniya.

Tea Control Department.

Bishop's College, Colombo.

Economic Division, Ministry of External Affairs.

School of Agriculture, Kundasale.

Government Girls' College, Colombo.

Muslim Training College, Kandy.

Department of Commerce, Colombo.

REPORT OF THE LOW-COUNTRY ADVISER FOR 1961

A. W. R. Joachim, O.B.E., Ph.D., F.R.I.C.

General —The crowning event of the year was the purchase of a suitable estate for the sub-station after five years of steady endeavour. Thanks to the co-operation of all concerned, the Kahahengama Division of Palmgarden Group came into the possession of the Institute on 1st December, 1961, and was graciously renamed "St. Joachim Estate " by the Board. The estate consists of 416 acres of land of which 326 acres are under tea, 51 under rubber and 25 under paddy. It has no factory, but discussions have been initiated with the engineering firms for the designing of a modern factory that will amply cater for the present crop as well as for the appreciable increase envisaged in the years to come through replanting with high-yielding, vegetatively-propagated material. In view of the unavailability and inadequacy of the necessary quarters for estate staff, the management of the estate for a period of six months has been entrusted to the Agents of Messrs Saffragam Rubber & Tea Co. of Ceylon, Ltd. These quarters will be constructed as quickly as possible and the management of the property will thereafter be taken over by our own staff.

A Buildings Committee has been appointed and this Committee has already taken in hand the organisation of essential building work for both estate needs and the research unit. Steps have been taken to advertise for the posts of Superintendent and Agronomist for the sub-station. Staff of the Intermediate and Junior grades, in addition to those now in the Division, will be appointed as soon as quarters become available.

The following changes of staff were made during the year: Mr U. L. M. de Silva, Technical Assistant was temporarily transferred to the Advisory Division at St. Coombs; Mr H. B. Ratnayake, O. I. C., Clonal Proving Station, Kottawa, was transfered to Hantane on 1st December, and was succeeded by Mr K. H. G. Gunapala. Mr S. K. P. Tambimuttu was appointed stenographer as from 1st January 1961. Messrs K. S. Sirisena and H. T. S. Hewagama assumed duties as Field Attendants at Kottawa on the 28th November and 4th December respectively.

Visitors to the Division included Mr F. C. Bawden, F. R. S., Director Rothamsted Experimental Station, and Professor Bennet Clark, F.R.S. (both members of the Scientific Advisory Committee in the U. K.), Mr N. G. Gokhale, now Director of the Tocklai Experimental Station, and Dr D. N. Barua, the Plant Physiologist of that station.

I acted for the Director from 19th June to 30th July, and have served as a member of the National Education Commission from April.

Advisory and Extension Activities.—The number of letters sent during the year was 1,585, an excess of 165 over last year. Altogether 19 meetings were attended. These comprised among others, meetings of Low-country Planters' Associations, the Experimental and Estate Committee, and the Low-country Committee of which four meetings were held during the period.

The Division collaborated actively in the proceedings of the Institute's Biennial Conference held in Colombo in January. Two papers were read

relating to the subjects of green manures and shade trees, and manuring responses in the low country respectively.

The number of visits to estates was severely restricted because of the enlarged experimental programme and the increased administrative work. Apart from numerous visits to the experimental centres at Palmgarden, Endane, and Kottawa, 20 visits were made to estates for advisory or observational purposes. Advice was otherwise given by correspondence or discussion whenever this was sought. In this connexion, a simple experimental design was provided for the conduct on estates of trials with a new soluble compound fertilizer for tea. This is now on test on two estates in the low country.

At the instance of the Minister of Agriculture, Land, Irrigation and Power, I reported, with the co-operation of the Revenue Officers concerned, on areas suitable for development as State Tea Plantations in the Ratnapura, Deniyaya, and Galle Districts. A reconnaissance of an area proposed for tea cultivation in the hinterland of the Hambantota District bordering on the Deniyaya area was carried out and a favourable report made thereon. Other areas in the Matara District were also reported on for their suitability for Tea Colonization Schemes. Relating to these surveys and estate investigations, 96 samples of soil were examined for pH (soil acidity) in the Division.

Kottawa V. P. Station.—The quarters of the officer in charge and the office and field laboratory have been completed. Water service has also been installed in these buildings.

The Plant Physiologist's clonal trial plots have been planted out with 32 clones selected from among 84 tested out in the nursery. The number of casualties has been very small. Of these clones the following are reported to be doing well: T 5/35, EN 31, TRI 777, MT/BG, NL 3/1, UH 9/3, Cy 9, KEN 16/3, T 5/3, POR 26, DG 39, TRI 2151, GMT 9, PAS 22, TRI 2023, TRI 2027 and TRI 2026, and the following appear so far to be slow growers : K 136, CR 4, DT 1, TRI 2025, N, CV 5/B1, BG 18, QT 1/5, KEN 15/7, CV 4/B1, TRI 2024, NL 4/2, TK 48 and K 150. Multiplication plots of 73 clones have been established for observational purposes and for taking cuttings.

A spacing and manuring trial to test the effects of three spacings at three manurial levels with three clones—TRI 2024, TRI 2016 and QT 4/4—was started in October. The experiment is laid out in a single replicate of 3 blocks of 9 plots each, the treatments being appropriately confounded to test major effects and first-order linear interactions only. Differential manuring will be carried out as soon as the bushes come into plucking.

A temporary shade-and-mulch experiment has been started by the Plant Physiologist's Division on clone TRI 2024, and a trial to test the effects of eelworms on tea under the soil and climatic conditions of Kottawa was carried out by the Nematologist. This trial has indicated that eelworms do not survive at the soil temperatures obtaining in the area.

Demonstration plots of Guatemala grass manured differently have shown that, on the Kottawa soils, an adequate amount of nitrogen is of primary importance for the good growth of the grass. Purpling of the leaves and stalks occurs in all plots, whether treated with additional phosphate and potash or not, particularly during dry weather.

Research.—The experimental programme undertaken by the Division during the year comprised: (i) manurial experiments at Endane on old seedling tea; (ii) manurial experiments on young V. P. tea at Palmgarden estate; (iii) statistical studies on experimental procedures with tea as applicable to low-country conditions; and (iv) a preliminary investigation on the relationship between rainfall and yield of tea in the low country, with particular reference to the average monthly precipitations during certain periods of the year.

1. **Manurial Experiment at Endane.**—This experiment completed its fourth cycle at the end of October after 63 weekly pluckings. The results for the entire cycle are as follows :

TABLE 1 ENDANE

		lb. green weight per acre	% of mean
Nitrogen	0 lb. per acre	7,783	97.9
	40 lb. ,, ,,	8,046	101.6
	80 lb. ,, ,,	8,007	100.7
Potash	40 lb. ,, ,,	8,003	100.7
	60 lb. ,, ,,	7,916	99.6
	80 lb. ,, ,,	7,919	99.6
Magnesium	0 lb. ,, ,,	7,874	99.1
	20 lb. ,, ,,	8,063	101.5
	40 lb. ,, ,,	7,901	98.1
	Average	7,946	100.0

The statistical examination of the data indicates that, once again, there are no significant differences in yields between treatments. What is most surprising is that the plots which received no nitrogen are, on the average, only about 3.2 per cent lower in yield than those receiving nitrogen at 40 and 80 lb. per acre per annum. Yields from the controls were, however, dropping steadily towards the end of the cycle and it appears probable that significant differences between the control and the nitrogen treatments would show up in the new cycle. The reasons for the unexpected results obtained are not apparent. The Chemist's observation that soils from plots which received no nitrogenous fertilizer for a year contained as high amounts of ammonia and nitrate as those which were manured with nitrogen, furnish a possible clue to our findings. The soil of the experimental area is comparatively rich in organic matter, and plots contain reasonably good stands of green trees. It is, therefore, likely that these leguminous trees and their loppings, which amount to over 5 tons per acre per annum, have arrested the rapid decline of yields which would otherwise have occurred.

In connexion with this experiment, estimations were made about a fortnight after pruning of the amounts of dry matter contributed by the leaf mulch to the plots. The average figure of 3,475 lb. or 1.55 tons per acre was obtained. This is higher than that estimated by Visser in an earlier experiment (Visser, 1960), and is probably accounted for by the fact that it includes both the pruning foliage and leaf droppings prior to pruning, as well as the organic residue from the green manure loppings.

In the fifth cycle of this trial, the manurial levels of the previous cycle will be maintained. In view of the high incidence of Shot-hole Borer in the area however—measurements by the Entomologist having shown that there were as many as 114 galleries and 151 live stages per 100 units of young wood—and in order to ascertain its effect on yield, two of the blocks were sprayed with Dieldrex 20 soon after pruning, and this was followed by spraying with Arkotine D 18 to safeguard the crop against Tortrix. Further, owing to the prevalence of symptoms of zinc deficiency in certain plots, two of the remaining blocks were sprayed with a 1½ per cent solution of zinc sulphate—Teepol being the wetting agent—at the rate of 50 gallons per acre.

The first tipping of the bushes was carried out towards the end of December. Plots receiving no nitrogen and no magnesium record appreciably lower tipping weights than those supplied with these nutrients.

2. **Palmgarden V. P. Manurial Experiments.**—(*a*) *Nitrogen, Potash, Magnesium and Frequency Trial.*—This experiment, on a 5-acre block of four-year-old clonal tea (TRI 2023), completed its pre-treatment phase with the pruning of the bushes in the first week of June. The yield data of the 95 trial plots showed average variations of from 3.52 to 6.44 lb. of flush per plot per plucking over 68 pluckings at 5-day intervals, with an overall average of 4.56 lb. Taking the data from first recording of crop to pruning (9-6-60 to 29-5-61) as representing a year's crop, the average yield per acre of the area is calculated at 3,535 lb of made tea per acre per annum.

The average yields per plucking were also examined to obtain some idea of how long after manuring the bushes begin to show the effects of the fertilizer mixture applied. Depending on the rainfall—extremes of high and low precipitations prior to plucking both being disadvantageous to production of flush—the effects of the fertilizers begin to show in as short a period as 12 days and within a month after application in all cases. The benefits of the fertilizers appear to have been experienced up to about 2½ months from application.

For the experiment proper, 9 blocks of 9 plots each were selected from the total number of plots so that all the plots in a block had about the same order of yield. The first manurial application was given in August and two other applications were made subsequently. Two modifications in treatments were introduced: (i) the levels of potash were reduced to 50, 100 and 150 lb. per acre per annum, and (ii) the frequencies of application were increased to 5, 7 and 9 per cycle.

Before manuring was started, a test was made to ascertain whether the application of a mixed fertilizer dressing (12.5%N) of 4 oz. each to 2-year-old V. P. tea bushes (equivalent to over 1,000 lb. per acre) was harmful. No adverse effects whatsoever were noted when the fertilizer was evenly broadcast between the rows of tea without forking. The rainfall subsequent to application was, however, heavy and fairly continuous in this case.

The plots in this experiment came into plucking on 21 September. Yields to the end of December, after 20 pluckings, are furnished in Table 2.

TABLE 2 PALMGARDEN

Treatments	lb./acre/cycle	Totals for 27 plots—lb.	Yield/plot lb.	%
Nitrogen	150	1844.5	68.3	100.0
	300	1924.6	71.3	104.4
	450	1956.4	72.5	106.4
Potash	100	1943.0	72.0	100.0
	200	1939.3	71.8	99.7
	300	1843.2	68.3	94.9
Magnesium	0	1904.0	70.5	100.0
	48	1927.4	71.4	101.3
	96	1894.1	70.2	99.6
Frequency	5	1874.6	69.4	100.0
of application per	7	1888.8	70.0	100.8
cycle (times)	9	1962.1	72.7	104.7

It will be observed that variations in nitrogen level have already been reflected on crop yield, a difference of over 6 per cent. being observed between plots receiving the highest and the lowest levels of nitrogen. The other nutrients have not, so far, affected yields appreciably, though potash at the highest level appears to have decreased yield somewhat. A comparison of the yield averages of the corresponding plots before and after the different potash treatments indicate, however, that this decrease of yield is more apparent than real.

(*b*) *Phosphate Experiment.*—Twelve of the plots which were not being used for the experiment discussed at (a) above, were used to ascertain the effects of phosphates applied at 25, 50 and 75 lb. of P_2O_5 per acre per annum respectively. A randomized-block design was adopted for the trial. Nitrogen, potash, and magnesium, were kept constant and applied at the normal rates on Palmgarden Estate. So far no differences in yield have been observed.

(*c*) *Decline-in-Yield Trial.*—The two remaining plots of the series of 95 plots, yield records of which had been maintained before the application of the treatments, were left unmanured in order to study the effects of a cessation of manuring on young V. P. tea producing about 3,500 lb. per acre per annum in its non-pruned year. In a period of about 3½ months, the yield of these plots had fallen by about 25 per cent on their previous average. This observation is in marked contrast to what was noted at Endane on old seedling tea where, over a period of 15 months from cessation of manuring, yields had not fallen significantly.

3. **Statistical Investigations.**—(*a*) *Size of Plot and Standard Error in V. P. tea.*—The pre-treatment data of the Palmgarden trial were used to calculate the coefficients of variability of plots of V. P. tea of sizes ranging from 1/57th to 3/19th of an acre. These decreased from 8.4 to 4.0 per cent. per plot with increase in size of plot, when positional variance was not eliminated, but only from 7.9 to 7.1 per cent. when this was done. The percentage standard errors in our trial are appreciably lower than those obtained by Eden on seedling tea of comparable plot size (Eden, 1931).

(*b*) *Recording of Crop Yields as Fresh Weights at Alternate Pluckings.*—The investigation to determine the validity of recording, in field experiments with tea, yields as fresh weight of leaf from alternate pluckings, was completed at the conclusion of the fourth cycle of the Endane manurial experiment. The data confirm what was reported previously (Visser, 1958; Joachim, 1961), namely that this procedure is quite adequate for estimating significant differences between treatments in relation to experimental error. Tables 3, 4 and 5, illustrate these points.

TABLE 3

Dry/Fresh Weight

1. Treatments per annum			%	2. Blocks		%
Nitrogen	0 lb/ac.	(N_o)	19.92	Plucked	A	18.46
	40 ,,	(N_1)	19.89	on first	B	19.23
	80 ,,	(N_2)	19.83	day	C	20.07
Potash	40 ,,	(K_o)	19.92	Plucked	D	19.77
	60 ,,	(K_1)	19.86	on second	E	20.56
	80 ,,	(K_2)	19.86	day	F	21.25
Magnesium	0 ,,	(M_o)	19.93			
	20 ,,	(M_1)	19.85			
	40 ,,	(M_2)	19.86			

TABLE 4

	Degrees of freedom	Correlation coefficient (r)	(r significant P=.01)
Treatments	26	0.99	.4869
Blocks	5	0.49	.9172
Error	130	0.99	< .2540
Total	161	0.88	< .2540

TABLE 5

(Alternate plucking/actual weights) ×2

N_0	N_1	N_2	K_0	K_1	K_2	M_0	M_1	M_2
101.2	101.4	100.7	100.7	101.0	101.6	101.2	101.4	100.5

It has, however, also been clearly demonstrated that the systematic recording of plot yields block by block in the same sequence on each occasion results in a definite bias, the blocks plucked earlier having lower dry-weight/fresh-weight ratios than those plucked later (Table 3). The correlation ratio between fresh and dry weights in the case of blocks (Table 4) also confirms this finding. The necessity to avoid this source of error is, therefore, obvious.

The data of Table 3 also show that the application of nitrogen and other fertilizers in the amounts specified does not alter the dry matter content of the flush to any significant degree.

(*c*) *Yield of Seedling Tea in Relation to Size of Bush.*—Measurements of the circumference and cross-sections of random samples of 14 bushes each per plot were made to ascertain the correlation, if any, between yield and size of bush in the Endane manurial trial. No relationship was apparent between average treatment and block yields and average size of bush, nor between average yield of plot and bush size. The correlation ratio between treatment yields and the product of size and bush number (total bush area) worked out to 0.62.

(*d*) *Manganese and Crop Yields at Endane.*—The Chemist's data on the manganese content of leaves from the Endane plots were utilized to study the relationship, if any, between this factor and yield. The statistical examination revealed that (a) there was no linear correlation between yield and manganese *within the limits* of the content of this element in leaf samples from the plots, the correlation being as low as 0.085; (b) there were indications that reduced yields, though not statistically significant, were associated with both low and high contents of manganese in the leaf, more particularly the former. The curvilinear regression equation $y=451+38.2x-5.16x^2$ gives a fair approximation of the relationship between the two factors, though this regression itself is not statistically significant. The third cycle data are shown in Table 6 as being typical of the relationship between the two factors.

TABLE 6

Manganese and Yield

Units of Manganese	1	2	3	4	5	6	7	8
Number of plots of each	3	9	27	20	21	61	19	2
Range of yields (lb)	386 to 500	366 to 493	403 to 629	449 to 631	449 to 661	408 to 632	374 to 527	468 to 495
Average green weight of leaf per plot per cycle (lb)	467	469	493	520	513	508	486	491
% of mean	93.2	93.6	98.4	103.7	102.3	101.3	97.3	98.0

4. **Yield and Rainfall in the Low-country.**—In an endeavour to ascertain to what extent yield is influenced by rainfall under low-country conditions, a number of typical estates were circularized for relevant information on the subject and a start has been made with the examination of the data furnished. So far it is apparent that, provided it is not markedly aberrant from the norm, rainfall is not a limiting factor of yield—the annual precipitation over the greater part of the zone except in the Balangoda district, being both adequate in amount and generally well distributed. In Balangoda the July-August rains appear to be critical, but even to this finding there are exceptions. A significant correlation of 0.62 was obtained between the June-September rainfall and yield on one estate.

Many thanks are due to the Superintendents who responded so readily to my circular.

5. **Pest, Disease and Weed Control.**—The investigational work on Shothole Borer has been carried out by the Special Entomologist for the pest, Dr E. Judenko; and the Entomologist, Mr J. E. Cranham, at St. Coombs has been responsible for the organization of an experimental scheme of trials for the control of the pest on estates with dieldrin. A few low-country estates joined in this scheme. Reference should be made to the reports of these officers for a review of their findings.

The Plant Pathologist has continued his investigations on the maintenance-leaf fall complex and his sectional report will contain an account of the latest developments on this subject. In this connexion reference may be made to the reported occurrence recently in various parts of the low-country—Kalutara, Galle and Ratnapura districts—of a disease that has subsequently been identified as *Rhizoctonia* sp., characterized by brown to black lesions on the leaves of young V.P. and seedling tea. This is associated with a cobwebby type of white mycelium climbing up to the tip of the shoots and causing necrosis. Spraying with a 50 per cent copper fungicide at normal rates at 7 to 10 day intervals has been recommended for its control.

The incidence of Blister Blight was exceptionally severe on a number of estates owing to the heavy and continuous rainfall experienced during the greater part of the year.

Reference has already been made to the question of the rarity of soil nematodes at the high temperatures obtaining in the low-country. Further information thereon will be furnished in the Nematologist's report.

Owing to the exceptional rainfall conditions, the weed problem was also very severe in the zone during the latter part of the year, and weedicides came into use. Simazine and Fernoxone were tried out both experimentally and on a fairly large scale by a few estates, and the results were reported to be good.

6. **Tea Manufacture.**—Reference was made in last year's report (Joachim, 1961) to two series of tests carried out with an experimental roller lent by the

Institute to the Manager of Pelmadulla Group on clonal leaf grown on the estate. The analysis of the data of these tests will be referred to by the Technologist in his report. A third series of regular tests has just been completed on leaf from 9 clones and the 1954 Nilagama seedling tea. Reports were made by two firms of brokers in this instance, on the appearance of the samples of made tea—a standard system of marking for brightness and quantity of tip and dry leaf appearance being adopted by both firms. The data will be examined and reported on by the Technologist.

It is pleasing to record that just as drum withering was first introduced into Ceylon on a commercial scale on Endane estate, Kahawatte, in the low country—and has become an acknowledged success after much initial experimenting, so also can another low-country estate—Sirimewana estate, in the Galle district—claim to be the first to have tried out trough withering as a commercial venture. The results reported to date with this system of leaf wither in respect of initial capital expenditure, cost and ease of operation, and output of withered leaf per day, indicate that this unit is likely to become a popular item of equipment on low-country tea factories where withering facilities are limited.

7. **Conclusion.**—Average tea yields in the low-country continue to be good but, unfortunately, owing to the dislocation of our markets, prices dropped appreciably during the second half of the year and are now almost marginal from the point of view of economic production. Interest in replanting with high-yielding clones, however, continues unabated. Two or three well-known estates in the low country have now perhaps the highest acreages of V. P. tea in the Island.

With the new knowledge that the low country sub-station will bring to the aid of our planters from now onwards in respect of both tea cultivation and manufacture, the future for the low-country tea industry should be bright, if our traditional markets are safeguarded.

It gives me great pleasure, once again, to thank the numerous Superintendents of estates and others who have co-operated with us in many ways in our work, and particularly the Superintendents of Endane, Palmgraden and Pelmadulla estates—Messrs A. Watt, D. Ross and J. W. Craig—for the facilities they have so kindly offered us for conducting experimental work on their estates, and for collaborating with us in obtaining valuable information for the benefit of the low-country tea industry of the Island.

8. **Publications.**—Joachim, A. W. R. (1961). The shade-tree question and green manures. *Tea Quart.* **32**: 63-68.

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REPORT OF AGRICULTURAL CHEMIST FOR 1961

J. A. H. Tolhurst, B. SC.

Staff.—Attempts to fill the two vacancies for Research Assistants have been unsuccessful. Miss B. Piyasena joined the laboratory technical staff early in the year, and Mr S. Sundralingam was appointed at the same time to replace Mr A. H. R. Balthazaar, who had sought a transfer to the Technology Division.

I have continued to act as Biochemist, and in November commenced to act on behalf of the Chief Advisory Officer during his furlough.

A.—FIELD EXPERIMENTS

No major changes were made in the main trials which have been discussed in detail in earlier Annual Reports (Tolhurst, 1960, 1961). Two new trials were marked out on virgin land on St. Coombs, to study interactions between nutrient levels, shade, clonal type, and planting density. Fully buffered plots were planned, and advantage was taken of the relatively uniform topography to introduce an appreciable degree of confounding. The final designs were suggested by Dr S. C. Pearce, East Malling Research Station. Planting, using clones TRI 2024 and 777, is being done by St. Coombs Estate and my Division will not bear responsibility for the trials until the plants are brought into plucking.

1. Low-country Manurial Experiments.—(a) The manurial trial on Endane Estate concluded the fourth cycle, again with no significant effects. As a zero-N treatment had been introduced at the start of this 18-month cycle, this is, on the face of things, surprising. Zinc deficiency (*vide infra*) was diagnosed on the plots and on my suggestion the Low-country Adviser introduced a zinc sulphate treatment, by foliar spraying, on two of the six blocks. Two more blocks were sprayed with dieldrin after pruning, and it is hoped that the present, fifth, cycle will show to what extent zinc deficiency and shot-hole borer infestation are limiting response to manurial treatments.

Details of these supplementary treatments will be found in the Report of the Low-country Adviser, but mention is made here as a necessary preliminary to discussion of certain chemical investigations. During 1961, my Division started regular analysis of soil samples, from depths of 0-3in and 3-6in taken from two groups of plots. One group was selected in Blocks E and F where earlier work had shown the highest accumulation of manganese in the mature leaf, while the other group was sited in the low-manganese areas of Blocks B and C. Each of the three nitrogen levels, 0, 40, 80 lb. N per acre per annum, was represented by 4 plots regardless of other treatments. Sampling and extraction of the ammonium and nitrate fractions was done by Mr V. Mendis on Endane Estate itself. Manganese fractions were determined later on air-dry samples. Mature-leaf and flush-leaf samples were gradually included in the scheme. The most interesting feature to date is shown by the high levels of nitrogen in both of the horizons, with little variation due to proximity to manure application or to the N-treatment level. Climate effects were rather more pronounced. Up to 80% of the "available nitrogen" is in the nitrate form, and there is a suggestion that the higher proportions of nitrate are to be found in the soils from the "high-manganese" areas. From 30 to 100 lb. N per acre appear to be present in readily available forms in the top six-inch layer of the soil.

This investigation will continue, with modification, in the fifth cycle with particular reference to the expected decline in yield of the zero-N plots. This decline has already been hinted at by the yields during the latter part of the fourth cycle.

Foliar analysis has shown much less manganese and slightly more potash than were reported in the preceding Annual Report, and a full sampling from all plots appears to be desirable to obtain a true comparison. It is still not possible to explain the occurrence of frequent foliar symptoms of both potash and magnesium deficiency, throughout this trial, while there is a complete absence of response to K and Mg treatments, unless we do assume that unrelated limiting factors, such as zinc deficiency or shot-hole borer infestation. are exerting an over-riding influence.

(*b*) Mature leaf was taken from all plots of the Palmgarden Manurial Trial (Clone 2023) before treatments were actually applied. Full chemical analysis is in progress, but it is possible to say that potash levels appear to be lower than has hitherto been regarded as desirable. A level of 1% K_2O on dry matter may represent sufficiency for clone TRI 2023, but on the No. 3 Field NPK Trial on St. Coombs it would certainly represent deficiency, reflected by yield trends as well as by leaf symptoms. An interesting comparison may be made with the potash levels found in the Endane trial, mentioned above. These range from 1.6 to 2.2% K_2O, in comparable leaf.

The balance between potash and other nutrients has, of course, to be taken into account, and it is standard practice to analyse all such leaf samples for N, P, Ca, Mg, Mn. It is hoped to be able to collect frequent samples from this trial to offer a comparison with the programme already under way for other trials (*vide infra*).

2. **Phosphate Manurial Experiment: St. Coombs No. 13 Field.**—Staff difficulties earlier in the year forced us to delay tipping in this trial while other work was done, more particularly the need to have two new trials accurately lined-out in time for the Superintendent to plant at the desired time. Therefore tipping was done at 18″ into red wood, in August, one year after pruning. This may not have been a disadvantage, but it was not necessary in view of the improvement in the rate of growth which was first noticed in April-May.

Nitrogen deficiency was visible before tipping, and the basal dressings of both nitrogen and potash was increased, to 120 lb. N and 60 lb. K_2O per acre for the first year of this cycle, the fourth. Subsequent years will receive 180 lb. N and 90 lb. K_2O. unless the yield potential warrants an increase.

Phosphate treatments were raised to 30, 45 and 60 lb. P_2O_5 per acre per annum, with the additional comparison between superphosphate and rock-phosphate remaining as before

Magnesium deficiency symptoms were removed by spraying a 4% solution of kieserite plus "Teepol" after tipping. A rate of 50 gallons per acre was sufficient to wet the foliage thoroughly on these rather small bushes.

Zinc deficiency symptoms were seen on neighbouring, older, bushes in May, and were later identified within the plots. One of the four blocks received a soil application of zinc sulphate at 150 lb. per acre, and two more blocks received two foliar sprays after tippings, each comprising 2.5 lb zinc sulphate in 50 gallons per acre. Further treatments are envisaged.

No yield trends are yet noticeable. Two blocks suffered from Blister Blight at a time when recovery from tipping should have been at its most vigorous, and this has undoubtedly delayed evaluation of a response to zinc.

3. N. P. K. Experiment: St. Coombs No. 3 Field :—Earlier reports on the vigour of recovery from the very hard pruning in 1959 have been more than justified. Potash-deficient plots have suffered by lack of branching from the original shoots, rather than by lack of primary shoots. This forces us to modify earlier opinions on the relation between recovery from pruning and previous manuring, with particular reference to phosphate and potash. Bushes deficient in either or both of these nutrients broke buds as freely as bushes under balanced N. P. K. manuring, and initial growth of the shoots was good. Phosphate-deficient bushes have shown less retardation of development of shoots than have potash-deficient bushes. There is no question of differential pruning; all bushes were pruned according to the amount of rotted wood which had to be removed and the overall treatment showed little variation between plots.

No plot had less than 60 lb. N in the year preceding pruning. If a practical conclusion is to be drawn, it is that a bush which is reasonably well manured can, up-country, stand up to very hard pruning, even to the extent of collar-pruning, and even though the frame is in very poor condition.

Plucking was eventually brought to an average of an 8-day round, removing shoots to the small fish-leaf whenever growth was vigorous, and allowing the plucking table to rise only slowly: less than 12 in. in 15 months of plucking. Even on the best plots there is still room for more branching to increase the area of the plucking table, but yields in the first year of plucking topped 1,100 lb. per acre. Graphing the monthly yields showed that these plots, at least, were still increasing their yielding capacity by the end of 1961. Thickening of the wood does not appear to have suffered as a result of the hard plucking.

The original nutrient levels were continued while assessment was being made of the several changes in management, even though it had been known for some time that this trial was undermanured with respect to nitrogen and, to a lesser extent, potash. By the end of 1961, when the response to the third manuring since tipping was partially evident, it became clear that the potential response to nitrogen, in particular, is far greater than was anticipated. Examination of monthly yields and meteorological data for the past cycles, back to 1931, suggest that the concentration of manure in one row, once a year, regardless of probable climate conditions and accompanied by a vigorous deep forking, may have lessened the response to manure very drastically. Accurate assessment is not possible without a knowledge of the plucking standards adopted

It is in the pattern of response to manure that this trial now appears to be giving its first result of practical value for a long time past. The first manuring, after tipping was followed by variable plucking, aimed at allowing peripheral shoots to develop unchecked. The second (March 1st) and third (October 15th) applications were followed by unexpectedly favourable weather, and uniform plucking. 1961 in fact provided almost ideal weather, in that yield-response to manure could be evaluated with little of the complications which usually make this task so difficult. Following broadcasting in both rows, with doses of 20, 30 and 40 lb. N, yields rose rapidly to a peak 7-8 weeks later and starting within 4 weeks.

Foliar analysis, of mature- and flush-leaf, has accompanied the yield-response study. We do not anticipate an easy answer to the problem of relating chemical composition of any given leaf to the probable requirement of the bush for various nutrients, but the manurial trials in existence offer ample scope for the research which will become the major part of my programme. For example, five leaf samplings were taken from this trial in 1961, and more are contemplated for 1962. All macro-nutrients and some micro-nutrients are being determined.

It may be mentioned here that an unreplicated series of 9 plots has been laid down to provide similar samples, in order to follow nitrogen uptake from annual doses of 150, 300 and 450 lb. N, divided between 2, 3 or 4 applications.

4. New Manures Trial: St. Coombs No. 9 Field.—After long delays in negotiating for the import of pelleted urea, it was possible to start a simple field trial in April 1961. Three forms of nitrogen are compared, each at two levels, replication being four-fold. In addition to sulphate of ammonia and urea, a combination of ammonium-nitrogen and nitrate-nitrogen is under test in the form of a granular NPK compound.

Three months' test plucking were followed by the first manurial appliation in June, the intention being to make 3 applications a year at either 25 or 50 lb. N. It was soon obvious that the plots were capable of yielding much more highly than anticipated, and doses were doubled in November. Yield differences between forms of nitrogen have been very small so far.

In deciding upon the feasibility of introducing new forms of manure into practice it is necessary to consider all the properties of the compound. Distribution in our plots, even though some mixtures may be damp and sticky, will be good whereas in estate practice a wet mixture would certainly be badly spread. It has long been my contention that distribution of manure, in estate practice, leaves much to be desired and we dare not run risks in recommending new manures which may lead to still more unevenness. It may be of interest to note that visible scorching on the foliage, on St. Coombs, requires doses of manure applied to the soil which are 50-100 times as great as should normally be applied to a single bush. In estate practice, therefore, for every bush showing manure scorch from excessive application to the soil, probably 50 bushes have had little or no manure at all. Scorch naturally occurs when the manure is carelessly scattered on the leaves.

Laboratory incubations were started in December to compare the results of mineralisation to ammonium-nitrogen and nitrate-nitrogen of sulphate of ammonia, urea, and a urea-formaldehyde plastic (18% N). This plastic compound, although expensive per unit of nitrogen, has possibilities in young tea manuring, especially for use in planting holes, as it cannot scorch, is absolutely dry, and appears to be converted to ammonium-nitrogen slowly and steadily. It is hoped that these incubations may also offer a clue to the reasons for the lowered efficiency of urea which has been found in field trials in tea in Assam.

B.—PLANT NUTRITION

The year 1961 has been peculiar in two respects. The installation of a photo-multiplier attachment for our spectrophotometer allowed us to contemplate an ambitious programme of foliar analysis, as noted above. At the same time attention had to be diverted to the study of two nutritional disorders of tea in the field, namely, deficiencies of boron and zinc. Neither has been reported previously for field tea, in any country, and there were therefore few short-cuts which could be utilised. The problem of coping with several types of work at one time fell largely on Mr T. C. Z. Jayman in the laboratory and myself in the field. Field work on boron deficiency, apart from the initial survey, did not develop to the extent which could have been desired, owing to the lack of staff able to carry out trials in districts often far removed from St. Coombs.

1. Boron Deficiency.—The first diagnosis was made on *Grevillea robusta* Cunn. The trees showed die-back of the tips of main branches, bud-clustering, necrotic lesions in the cambium, bark splitting and gum exudation, and arrested division of the leaves into definable pinnae. Dadap was soon recorded as a susceptible species, the symptoms showing particularly severely after lopping

and being typified by clusters of stunted and dying shoots spaced closely along branches and even on the trunk.

Tea near the end of the pruning cycle provided the first identifiable symptoms for this crop in the field, in the form of shoot die-back, swollen nodes, and clustered buds. Blunt, slightly up-rolled, mature leaves were often associated. Finally, reports of die-back of shoots soon after pruning led to the recognition of similar patterns of die-back at this stage of the cycle also. This die-back, sometimes extending to whole branches or even the whole bush, has occasionally caused concern where vigorous clonal plants have received their first prune.

The field survey concentrated on defining the probable areas of occurrence, using *Grevillea* and dadap as indicator species. It caused no surprise to find that the Uva District was generally prone to boron deficiency, since the abundance of quartzite rock poor in accessory minerals is well known there. The dark grey charnockite rocks of Haputale and Nuwara Eliya represent the eastern limit of the permeation of the older sediment by vapours and fluids containing boron, among other elements. Carbonate-fusion analyses of rock samples and soils showed that this was a reasonable explanation of the geographical distribution of boron deficiency. One area in Dimbula, coinciding with a pale, quartzite type rock, was found to be slightly boron-deficient; the area extends from Mayfield to the Queensberry Gap. No other cases were diagnosed outside Uva.

Foliar analyses in considerable numbers have been done. Anomalies have appeared, some of which can be explained by allowing for the obvious reduction in leaf size following death of the meristematic regions and cessation of growth. If such a leaf were to remain on the plant, which was later able to accumulate boron from the soil during monsoon months, an accumulation of boron might be expected without a corresponding increase in dry weight. The proportion of boron in the leaf dry-matter might thus vary widely depending upon the time interval between the onset of boron deficiency and the date of sampling.

Tentative recommendations have been put out for borate manuring, in Uva only, but we hope to be able to obtain more precise information as to the optimum rates for tea. It is necessary to study various die-back symptoms in tea in plucking, but the position is complicated by similar effects which may be produced by excessively hard plucking or by Blister Blight. With a disorder which is highly seasonal in occurrence, and in a district such as Uva where drought effects themselves are notorious, there is obviously the need for continuous observation of many small-scale field trials.

2. Zinc Deficiency.—By way of contrast, this disorder can be seen in tea in all districts although symptoms are more striking at the lower elevations. Symptoms in shade trees have not so far been defined but there is little doubt that they will soon be recorded for all the common species.

Zinc deficient tea, in severe cases, shows chlorotic, sickle-shaped, leaves of reduced size, clustered at the tips of shoots. Such shoots may be several inches below the plucking table, and may lead to the appearance of hollow centres surrounded by tufts of shoots which flush normally. The degree of chlorosis varies, apparently being more pronounced at lower elevations. An associated symptom, especially at higher elevations, is seen as up-rolled mature leaves with deeply-waved edges. These leaves are often very dark. The relation between these two dissimilar symptoms has yet to be determined.

Foliar sprays were used in the course of diagnosis and it is worth noting that tea is very tolerant of zinc sulphate solutions. No damage resulted from concentrations up to 4% by weight, either with or without a wetting agent. This contrasts markedly with the sensitivity of many plant species. Control

measures based on the addition of zinc sulphate to routine copper sprays, at 10-15 gallons per acre per round, thus appear to be practicable. It is tentatively suggested that a total of 10 lb. per acre per annum be sprayed adding ½ to 1 lb. of zinc sulphate per 10 gallons of spray for the requisite number of rounds.

Assessment of yield response to foliar spraying, at a volume of 50 gallons per acre, is in progress. In addition to the treatments noted above in the No. 13 Field Trial, two blocks of the New Manures Trial were also treated. One received two sprays, each comprising 2.5 lb. zinc sulphate in 50 gallons together with a wetting agent; the other received four such sprays. Within 5 months of the first spray, each of these blocks had increased its yield relative to the two remaining blocks, by nearly 20%. A 3-month pre-plucking period afforded a basis for the comparison. This yield differential has been maintained, and promises encouraging results. Zinc deficiency symptoms were mild in this area.

Other investigations are planned. Failure of apparently healthy branches to break buds after pruning occurs in No. 9 Field, St. Coombs, in an area now seen to be deficient in zinc. This is also the area noted in my Annual Report for 1960 as showing excessive accumulation of nitrogenous fractions in the lower leaves of tipping shoots, and inhibition of translocation of nitrogen to the young leaves. Small plots were treated with zinc preparatory to pruning in 1962, for further observation of these points.

Fewer foliar analyses have been done than in the boron deficiency survey, but it is clear that the diminution of leaf size introduces a similar difficulty in the interpretation of results expressed as a proportion of zinc in leaf dry matter. 12-15 p.p.m. is probably the critical region for both nutrients.

Since zinc deficiency has been identified in all districts, and often to a marked degree, this raises the question of cause. Symptoms are so characteristic that it is difficult to believe that so many could have passed unnoticed for very long. If the deficiency is of recent and sudden occurrence, we may speculate as to the responsibility of one of the constituents of the NPK mixtures. No proof is yet available, but this would not in any event affect the necessity for control measures as noted above.

3. **Miscellaneous.**—(a) Phosphate-deficiency symptoms became noticeable on some of the zero-P plots in the No. 3 Field NPK trial, and were identical in appearance with those noted at the end of the previous cycle. As in many species, the syndrome is vague, and would be unreliable for diagnostic purposes unless well developed. Mature leaves in the plucking table are large, thick and dull with a slightly roughened surface. The colour is a dark green with a purplish or bronzy suffusion distributed over the lamina. Young growth, which is not plentiful, is strikingly light in colour.

These symptoms, the first to be recorded under field conditions, are as described by de Haan from pot cultures (de Haan, 1941).

(b) Iron-deficiency symptoms, for want of a better term, were seen frequently, especially in rapidly growing clonal plants and again under a wide variety of conditions. Bushes in No. 9 Field, St. Coombs, which had been noted for this condition, were pruned so that recovery took place during the South-west monsoon. Symptoms re-appeared when growth of the new shoots became vigorous and were often restricted to the same branches on which they had appeared previously.

(c) Sodium compounds have been used in the past in many of my small-scale trials on tea, and it was noted that regardless of the anion, a characteristic scorching of the foliage often resulted. Application had been either to the soil, to the foliage by spraying, or into branches as solid-injection. Damage often persisted for months, and followed successive growth of new leaves. The syndrome suggested calcium deficiency and a small trial was laid down to attempt to decide this point.

(d) Manganese-deficiency symptoms were noted in No. 3 Field, St. Coombs, resulting from the dumping of weed-ash and wood-ash. This occurrence, the second to be recorded, is thus similar to that originally reported (Tolhurst 1954). Unimportant in itself, it may be of wider interest in considering the question of an inverse relationship between potassium and maganese. Tea growing in a limed plot on St. Coombs, and tea growing elsewhere in soil derived from limestone, show no manganese deficiency. Potash deficiency is, however suggested either by foliar symptoms or by chemical analysis in both these areas. Leaves from the manganese-deficient bushes in contrast, were high in potash. Soil-pH distribution was similar in all cases.

Plots were laid out in No. 9 Field to test the effect of raising the soil pH, to about 6.5, with ash from burnt tea stumps or with calcium hydroxide.

The question of a relation between excessive manganese uptake drought conditions, and potash-deficiency foliar symptoms, remains unanswered. An area at 6,200 feet elevation was observed where, on a soil almost purple with deposited manganese oxides, the tea showed none of the manganese-toxicity chlorosis, although 8,000 p. p.m. of Mn were present in the mature foliage. Potash deficiency symptoms were, however, plentiful. It is hoped to simulate drought effects by drilling into the wood, in an attempt to induce chlorosis.

At lower elevations, and often aggravated by shot-hole-borer damage, such chlorosis is common enough, and there can be no doubt that the bush suffers, certainly during the drier seasons. This chlorosis has been induced on St. Coombs by injecting heavy doses of manganese sulphate into holes drilled into the branches. Soil application, as reported in 1960, gave rise to potash deficiency symptoms and no chlorosis, even though manganese accumulated to over 5,000 p. p.m. in the foliage. Much work would be needed to follow up the complexities which were obviously presented.

While tea has proved to be very tolerant to many of the less common heavy metals, in particular molybdenum, as judged by visual assessment of solid injections into branches it has been found that lithium compounds readily cause damage. Absorption from soil application of lithium salts is also rapid. The syndrome is characteristic, and lithium contents in the upper-most mature leaf were found to be over 100 p. p.m. Li, compared with a normal 5-10 p. p.m.

Lithium would appear to be useful, therefore, in certain types of experiments, viz: tracing root development, etc.

Progress has been made towards publication of a monograph containing illustrations of all the nutritional symptoms recorded up to the present.

C.—GENERAL

Manuring.—The first changes in our recommended manure mixture for mature tea were made in 1961 (Tolhurst 1961 b). Evidence from No. 3 Field N. P. K. Trial was deemed sufficient to support a reduction in the over-generous proportion of phosphate in T. 500. T. 500 was first proposed by Dr R. V. Norris in 1950 as a guide, with no intention of being the best mixture for all conditions for all time. Conditions have changed greatly since 1950 and our ideas are

changing also, perhaps still more rapidly than would appear from the introduction of the new T. 700 series. This series is intended to encourage a flexible attitude of mind towards nutrient ratios in mixtures. In particular, it leaves the way open for selection of a variety of potash-rich mixtures, aimed especially at low-elevation tea. With very high rates of manuring we may eventually consider reducing phosphate once more.

Young-tea manuring was listed (Tolhurst, 1961c) with no change in nutrient ratios. The reason was not that we felt that T. 200 represented the ideal mixture, but that we anticipate field trials which will give precise information in a short period.

The Provisional Nursery Manure (Tolhurst and Visser, 1961) must be accepted in the same way. Manuring techniques for both nursery-tea and young tea could be many and varied, and more experiments should be done under estate conditions.

Much attention has been devoted, by the Institute, to the question of rate of manuring of mature tea. If anything is clear, it is that many factors complicate the assessment of a relation between past manuring rates and yield trends. Prediction of future trends is naturally still more difficult.

Our past advice has been based on a variety of "ratio" systems, themselves evolving from a parent "replacement" idea. Further evolution in our thinking, an essential process in scientific research, has led to the decision to abandon "ratio manuring", as an advisory practice.

My own suggestion, for an alternative scheme aimed at allowing an assessment of economic manuring rates on individual estates, would be to encourage experiments on a basis which we habitually use in our own trials. It would be practicable for an estate to group some, or all, fields into three categories of manuring separated, say, by 30 or 40 lb. of nitrogen (in a balanced mixture). These rates should be maintained even in the pruning year, they should not be reduced, and if yield trends prompt an increase then they should all be stepped up by a similar amount. Good and poor fields should be fairly represented in each manuring category. From the records obtained, after a few years, the Institute could draw reasonably accurate conclusions which would pertain to the conditions on each estate.

As has been clear from my earlier Annual Reports, rate of NPK manuring is only one of the aspects of the whole manuring question. The Division of Agricultural Chemistry tends to specialize in problems of distribution and of the balance of nutrients.

D.—ST. COOMBS OBSERVATORY

Early in the year, the observations were taken over by my Division, Mr. T. C. Z. Jayman being officer-in-charge.

E.—PUBLICATIONS

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REPORT OF THE CHIEF AGRONOMIST FOR 1961

H. N. Hasselo, Dr, Ir.

A. General—I arrived in June and took charge of the new Agronomy Division. Mr W. B. Manipura, B.Sc. (Cey.) was appointed Research Assistant on 1st October.

B.—Shot-hole Borer.—The effect on the yield of tea of the control of Shot-hole Borer by dieldrin spraying was statistically analysed for three of Dr Judenko's experiments in the Kandy area (Judenko 1960, 1961). The results obtained in the first 18 months after spraying showed that the recovery after pruning was quicker, the number of galleries counted in the newly formed wood was smaller, and the yield was larger, in the sprayed as compared with the unsprayed bushes. Detailed results will be published in the Tea Quarterly.

C.—Depletion of Root-starch Contents.—In co-operation with Mr J. Rimington of Glenlyon Estate, a short-term trial was laid out to find out to what extent the starch content of tea roots can be reduced by cultural or chemical methods. The following were the treatments in a Latin-square design :—

1. control—no treatment;
2. slashing (low-cut pruning);
3. foliar spray of a 10% Urea solution;
4. foliar spray of a chemical growth stimulant (2, 4-D).

If much reduction of starch could be achieved and if root with a low content of starch is not so prone to attack by *Poria* root disease, then it might be worth while to reduce the root-starch content intentionally some time before uprooting for replanting, so as to avoid the expensive operation of digging up the tea roots in *Poria*- infested areas or at any rate to reduce the ill-effects of incomplete eradication. This subject is being studied in co-operation with the Plant Pathologist.

D. Fertilizing Tea in Ceylon.—1. The Replacement Principle.—The manuring policy in tea in Ceylon has in the past years been based upon the replacement principle, namely, that the quantities of main nutrients supplied should be proportional to the estimated amounts of these nutrients removed in the crop harvested since the previous fertilizer application. The amounts removed in the harvested crop and prunings were assessed by Eden (1949) by chemical analysis of plant tissues. In this way a formula was worked out, called the replacement ratio (Lamb 1954; Lamb, Portsmouth and Tolhurst, 1955). The maintenance ratio, also called the ''eight-pound-N ratio'', amounts to an application of approximately 8 lb. of nitrogen (N), 4 lb. of phosphorus reckoned as P_2O_5, and 4.5 lb. of potassium as K_2O per 100 lb. of made tea; this mixtrue at this amount was intended to allow for losses occurring from the soil. Since 1954/55, various changes have been made both in the 8-lb. ratio and in the relation between amounts of N, P_2O_5, and K_2O (Tolhurst, 1961).

2. Is the Concept of Ratio-manuring Sound?.—The concept of ratio manuring implies that there is a corresponding efficiency of the plant in taking up the applied nutrients. Thus an 8-lb. ratio may be taken to imply that 12½ lb. of

made tea is produced per pound of N applied, while a 10-lb. ratio implies the production of 10 lb. of tea per pound of N. The logical extension of this relationship is that the yield would be nil if no fertilizer were applied. This is clearly unsound.

In the first place, results from trials and also common experience in Ceylon, India, Nyasaland, and Kenya, show that yields obtained over a long period of years *without* the addition of any fertilizers range from 400 to 1,000 lb. of made tea per acre per annum. For example, plots without fertilizer at St. Coombs yielded 400-500 lb. of tea per acre during nine pruning cycles. The nutrient-supplying power of tea soils is in fact considerable and may account for roughly half the average yield obtained in Ceylon. Therefore, the ratio principle, which (by inference) ignores the contribution made by Ceylon tea soils towards plant nutrition, is fundamentally wrong and may give a distorted picture of the profitability of fertilizing. In terms of economics of fertilizing, an 8-lb. ratio would seem more efficient and hence more profitable than a 10-lb. ratio. Both the implication of a difference in efficiency between the two ratios and the assumption that they produce 12½ lb. or 10 lb. of made tea for every pound of nitrogen are incorrect. This was demonstrated with the help of data collected by Visser in 1958 and 1961 (Visser, 1962) and can also be derived from the data of Joachim (1961). These data show that there are very few estates indeed where one pound of nitrogen produces 10 lb. of made tea, and none that produce 12½ lb., even if the whole rise in yield is assumed to be due to fertilizer and none of it to good management and favourable conditions.

In reality the over-all effect is much less than may be inferred from the expressions 8-lb. ratio or 10-lb. ratio. At the very most, as found in plot trials in Ceylon, there is an increase of 6.4 lb. of tea per pound of nitrogen applied, *irrespective* of the ratio used (Eden, 1959). The possibility that a true nitrogen efficiency of 12½ lb. occurs is indeed remote.

The idea that an 8-lb. ratio is a 'maintenance' ratio has developed the corollary idea that a 10-lb. ratio is an 'expansion' ratio, suggesting that this rate of NPK application would lead to an expansion of crop. Practical experience and experimental evidence suggest that this might be so in many cases, but it is contrary to the statement "there is a common fallacy that the growth of the tea bush may be stimulated by so-called artificial manures" (Lamb, 1953). In practice the use of the concepts expansion and maintenance (replacement) ratios may lead and sometimes has led to the belief that once having "expanded" the crop one can go back to the maintenance ratio and thus "maintain" the crop level one has earlier obtained with the expansion ratio. In most instances, however, this is likely to result in a subsequent decrease of crop, as after all one would reduce the amount of fertilizer applied *per acre* by 20% when changing from an expansion ratio to a maintenance ratio.

A further aspect of the concept of ratio-manuring is that 'replacement' is used with reference to the main nutrients N, P and K only and not to equally important nutrients Ca, S and Mg, nor to the trace elements. This may create the impression that some elements need to be replaced in proportion to the amounts removed in the crop, but others do not.

The fact is that the replacement idea, as developed in Ceylon, is incorrect. Under some conditions particular nutrients need not be replaced at all and the amounts of others applied should be far larger than the amounts removed in the crop.

3. What are the dangers in following the replacement concept ?—The acceptance of the replacement principle, as developed in Ceylon and whether called the maintenance or expansion ratio, entails the practice of calculating application rates on immediately previous yield. This means that after a year when

yield has been low, e.g. due to unfavourable weather conditions, the amounts of nutrients applied will be lower in proportion. It is commonly accepted, however, that crops fertilized at sub-optimal rates are more prone to suffer from adverse conditions (van der Paauw, 1958; Hasselo, 1960, 1961), so that any lowering of fertilizer applications under such conditions will only enhance the adverse effects on yield, causing it to tend to decrease still further.

An inherent danger in the replacement concept is that of sponsoring expenditure on fertilizer on low-yielding estates, expenditure that is excessive in relation to the yield obtained. Consider, for example, an estate that has been applying 40 lb. of N. per acre (calculated on a 10-lb. ratio) and has achieved a yield of 400 lb. of made tea per acre. Now, of course, the yield obtained is the result not only of the fertilizer obtained but of the very many factors which in the broad sense, comprise 'management', e.g. the suitability of pruning, plucking, and general cultivation, and the adequacy of supervision. In most cases, an estate should be able to produce at least 400 lb. with no fertilizer at all. It follows that value is not being obtained in the above instance for the money spent on the fertilizer.

On the other hand, well-run high-yielding estates may find it difficult to raise their yields above a certain point on the 8-lb. or 10-lb. ratio and the system will then result in limiting of yield, unless a rising series of ratios is used.

During the years when the replacement principle has been followed, it is of course a fact that yields of many estates have risen greatly. This, however, has occurred in spite of the principle rather than because of it. For the ratio principle claims that once the yields have been expanded by a 10 lb-N ratio or more, a maintenance dose, i.e. a reduction to an 8-lb-N-ratio dose, will be sufficient to maintain the yields at the higher levels obtained with the expansion rates.

4. Conclusions.—The conclusions are: (a) that the concepts replacement ratio, maintenance ratio and expansion ratio as interpreted in Ceylon are incorrect; (b) that a better indication of the true relation between fertilizers and yields will be obtained if the principle is adopted of applying fertilizers on a lb/acre basis, independent of short-period fluctuations in yield; and (c) that an estimation of fertilizer amounts to be applied may be obtained from an appraisal of past yield and fertilizer trends and further from experimentation (Visser, 1962).

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REPORT ON BIOCHEMISTRY FOR 1961

M. S. Ramaswamy, B.Sc., A.R.I.C., A.I.I.Sc.

General.—Two Assistants were added to the Division: Mr V. Fernando was promoted to this grade from 1st March and Mr K. Sivapalan, B.Sc. (Ceylon) assumed duties on 1st April. The increased staff continued to work in restricted laboratory space, but the new building, to which this Division is to be moved, is expected to be ready during 1962. The necessary equipment for the laboratory is being collected in stages.

While in Europe I took the opportunity of visiting the chemical laboratory of the Indian Tea Association (London) at Butler's Wharf and also Dr Bendall's laboratory at Cambridge University. I am very much indebted to Dr E. A. H. Roberts and Dr D. S. Bendall for showing me round their laboratories and for very useful discussions regarding biochemical problems of tea.

RESEARCH

Apart from the investigations on the composition of the green leaf in relation to the elevation and the climatic conditions in Ceylon tea districts, our work has been mostly concentrated on attempts to find a rapid physical or chemical method of selecting high-quality clones.

1. **Chemical composition of the green leaf obtained from tea districts at different elevations and under different climatic conditions.**—It was mentioned in the report for 1960 that, in relating the chemical composition of the tea liquors to the tasters' assessments of liquoring properties, consideration should be given to the effect of the well-known climatic differences of different tea districts in Ceylon which could affect the composition of the green leaf. This investigation was therefore undertaken to assess some of the inherent biochemical properties of the leaf grown at different elevations and in different climatic conditions with a view to finding out how far these properties continued to be exhibited by the made teas. For this purpose dried green-leaf samples obtained during 1959-60 for a different purpose (and referred to in the annual report for 1959) were used. The following constituents were determined since, as reported earlier, these constituents appeared to be related either directly or indirectly to the quality of the tea ;

(a) soluble solids ;
(b) total oxidisable substances;
(c) caffeine ;
(d) soluble nitrogen other than caffeine nitrogen;
and (e) soluble mineral constituents.

A mass of data collected was assessed for various relationships by simple statistical methods. A summary of the results is given here.

1. 1. **Effect of elevation on the composition of the green leaf.**—The statistical data are presented in Table 1.

TABLE 1. *Relation of elevation to average composition of the green leaf*

Constituents of the green leaf	Leaf from both the S.W. and the N.E. Monsoon zones		Leaf from the S.W. Monsoon zone only	
	Correlation coefficient (r)	Level of significance (P) (less than)	Correlation coefficient (r)	Level of significance (P) (less than)
Soluble solids	+ 0·29	—	+ 0·80	—
Total oxidisable substances	+ 0·57	—	+ 0·95	0·01
Caffeine	— 0·82	0·02	— 0·86	0·05
Soluble nitrogen other than caffeine nitrogen	— 0·73	0·05	— 0·73	—
Total soluble nitrogen	— 0·88	0·01	— 0·90	0·02
Soluble mineral constituents	— 0·88	0·01	— 0·98	0·001
Ratio, total oxidisable substances/ total soluble nitrogen	+ 0·74	0·05	+ 0·95	0·001

The results were found to be, to a large extent, consistent with those obtained for made teas, except that the result of (1) the soluble-solid content was statistically non-significant and (2) that of the total oxidisable substances of all the samples was also statistically non-significant. It may therefore be presumed that, to a large extent, the differences in the quality of the teas produced in different districts in Ceylon are likely to be due to the inherent properties of the green leaf.

1. 2. Effect of season (wet and dry) on the composition of the green leaf.— The statistical data are presented in Table 2.

TABLE 2.—*Effect of season (wet and dry) on the composition of the green leaf*

Constituents of the green leaf	Leaf from the S.W. and the N.E. Monsoon zones, dry season		Leaf from the S.W. Monsoon zone only, dry season	
	Mean % increase or decrease over the result for wet season	Significance (P) less than	Mean % increase or decrease over the result for wet season	Significance (P) less than
Soluble solids	3·3	—	3·3	—
Total oxidisable substances	6·4	0·05	9·2	0·02
Caffeine	5·0	0·05	6·9	0·01
Soluble nitrogen other than caffeine nitrogen	5·0	—	10·6	0·01
Total soluble nitrogen	5·1	0·05	7·4	0·01
Soluble mineral constituents	— 2·7	—	— 5·4	0·01

These results again are generally in conformity with the findings from the analysis of the made teas.

1.3. **The Inter-relationship between various constituents of the green leaf.**—An increase in the soluble-solid content of the green leaf was generally accompanied by an increase in its total oxidisable matter, but a decrease in the soluble mineral and nitrogenous compounds.

2. **Clonal Leaf.**—Further investigations were carried out on T. R. I. clones of known manufacturing properties, on the following lines :—

(a) assessment of groups of polyphenolic compounds;

(b) oxygen absorption studies (*in vivo*) and total oxidisable constituents ;

and (c) composition of the liquors of made teas (miniature technique) and its relationship to tasters' valuations.

2. 1. **Groups of polyphenolic compounds.**—Pending the arrival of the necessary equipment (automatic fraction collector, etc) to be used for the fractionation of the polypenolic constituents, an attempt was made to use alternate methods. Swain and Hillis (1959) have reported a rapid colorimetric method for the determination of groups of polyphenolic constituents in *Prunus domestica*. With a slight modification, this method was tried for the determination of the following groups of polyphenolic constituents in the dried green leaf from T. R. I. clones.

(a) total polyphenols;

(b) flavanols;

(c) leuco-anthocyanins;

and (d) anthocyanins.

It was found, in preliminary work, that in most of the clones anthocyanins were either absent or present only in traces excepting in one clone which was found to be rich in anthocyanins. Therefore, only the first three groups were subsequently studied. In all, about 80 clones were investigated.

The results were not found to be consistent with the quality group to which the different clones belonged. Even a single clone plucked on four different dates in the course of a week gave different results. Further work has to be done to discover a method for application to tea. However, on the whole, the clones belonging to the high quality groups appeared to contain larger quantities of these groups of constituents than the poorer varieties. A summary of the preliminary results is presented in Table 3 together with the results of the total oxidisable substances for purposes of comparison.

TABLE 3.—*Groups of polyphenolic constituents in TRI clones.* (*Average results expressed in arbitrary but comparative units*)

Quality of the clones (Group)	Number of clones investigated	Total polyphenols			Flavanols			Leuco anthocyanins			Total oxidisable substances % dry leaf		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
A1	7	839	432	570	668	569	640	469	143	325	36·1	26·2	31·4
A2	25	678	377	506	638	538	610	432	222	324	45·6	25·8	30·4
B	24	638	357	486	638	471	583	552	161	307	33·3	23·7	28·0
C	24	538	347	464	668	538	604	569	187	315	31·7	24·9	28·0

2. 2. Fermenting properties.—Further attempts to classify T. R. I. clones according to their fermenting properties will be made as soon as the new laboratory is available with a spectrophotometer (with reflectance attachment). In the meanwhile, "*in vivo*" studies were made on 25 clones belonging to various quality groups. The polyphenol-oxidase (PPO) and the pectin-methyl-esterase (PME) activities of the minced material were determined after 5 hours of fermentation. A summary of the results is shown in Table 4.

TABLE 4.—*Enzyme activity in TRI clones (PPO activity is expressed as ml O_2 absorbed and PME as mg methanol liberated by 100g leaf, dry basis)*

Enzyme	Group A1 (7 clones)	Group A2 (7 clones)	Group B (6clones)	Group C (6 clones)
PPO	721	759	673	685
PME	50·2	54·5	59·1	58·1
Ratio PPO/PME	14·4	13·9	11·4	11·8

There was a general indication that high quality clones exhibited higher oxidase and lower esterase activities than the poor varieties; this is in accordance with expectation. Consequently the ratio of the PPO activity to PME activity was found to be higher in the high quality clones than in the poor varieties. There were, however, exceptions, and further work has to be done before this method could be used for selection work. For example, one clone (W-3) of A1 quality (Keegel, 1959) showed a relatively poor oxidase activity, while two other clones in C group (KPW seedling and TRI 142) showed very high oxidase activity. Perhaps some of these inconsistencies could be due to lack or excess of substrates. This question was also looked into with the following results.

Clones showing a high polyphenolic content generally showed a high oxidase activity, while those containing low polyphenolic content mostly poor activity. In fact, there was a close positive and significant ($P < 0.01$) relationship between these two. Since the oxidase activity was determined under "*in vivo*" conditions, it appears safe to presume that the limiting factor in these clones regarding their fermenting properties is their polyphenolic content, and the enzyme is possibly always present in excess of the normal requirements. In fact clone W-3 (belonging to the A1 group), which showed a poor oxidase activity, was also found to be poor in its content of total oxidisable material (i.e. 26.2% against the group average of 31.3%); the clones KPW-seedling and TRI 142 (belonging to the C group) which showed a high oxidase activity were found to be rich in their total oxidisable matter content (i.e. 31.9% and 31.4% against the group average of 28.6%).

The following incidental information was obtained from this work;

(a) the relationship between the oxidase and the esterase activity was found to be negative and significant (P=less than 0.02);

(b) clones showing greenish liquoring characteristics were generally found to be rich in their PME activity (this finding is in conformity with earlier results).

2. 3. Composition of the liquors from teas made from different TRI clones and its relationship to the tasters' assessment of the liquoring properties.—It was stated in the annual report for 1960 that certain constituents of the liquors from teas made by the orthodox technique (factory) in different tea districts could be related either directly or indirectly to some of the liquoring characteristics. This work was undertaken with a view to finding out how far these

relationships held good when clonal material from the same elevation was manufactured by the miniature technique and analysed. For this purpose, ten TRI clones belonging to different jats (as judged by the size of the maintenance leaf) were manufactured on eight different fortnightly plucks (80 manufactures in all). The liquors from the 5-minute brew were analysed and the tasters' reports on samples were obtained. Of all the constituents, only the theaflavin content of the liquors appeared to increase as the tasters' valuation for the quality of the liquors, the colour of the infused leaf, and the market value, increased. The results were highly significant (significance $P < 0.001$). Regarding other constituents, it has been shown above that they are probably inherent in the bushes grown at different tea districts.

In view of this finding, a broad survey of a number of TRI clones is being undertaken to determine the optimum conditions of (a) withering, (b) period of fermentation and (c) temperature of fermentation required for the maximum production of the theaflavins.

3.—Physical and chemical properties of the leaf from different jats.—The basic idea behind this investigation was to find out whether a rapid physical or chemical method could be evolved for V. P. selection work; the process of miniature manufacture and tasting which is adopted at present in selection work is laborious and time-consuming. For this work, the quality of the flush from individual bushes is postulated to be genetic in nature and, if it is, this may be related to other genetic characteristics of the bush, for example, the size of the maintenance leaf which is found to vary in different tea jats.

In a preliminary trial, a number of bushes varying in the size of their maintenance leaves was selected in a neighbouring estate field (we are grateful to the Superintendent of this estate for his permission to pluck the maintenance leaves and the flush from these bushes). About 20 to 30 maintenance leaves and the flushes above these leaves were collected. Measurements of the length (along the midrib) and the breadth (at the broadest region) of the maintenance leaves were taken. The flushes were dried and analysed for various constituents. Statistical analysis of the data showed that none of the constituents examined was found to be related to the leaf measurements except for a positive and significant ($P < 0.02$) relationship between the ratio, length/breath and the total oxidisable substances. In other words, there is an indication that bushes with high L/B ratio of the maintenance leaves i.e. relatively narrow ones, produce quality flush. Further work is, however, necessary to confirm this.

Since sufficient leaf from single bushes could not be obtained for a miniature manufacture, analysis, and tasting, this investigation was extended to a TRI clonal block. The details of the experiment are given in section 2.3 of this report. Apart from the flush, about 20 maintenance leaves were also collected during each pluck for taking the leaf measurements. The results were, again, not encouraging. Analysis of variance showed that the size of the maintenance leaves varied from pluck to pluck. Only the soluble mineral constituents of the made teas showed a significant and positive relationship with the leaf measurements. Tasters' valuations of the made teas generally showed a preference for the bushes with large maintenance leaf. However, the general assumption that the small-leafed varieties produce quality teas may be due to the presence of constituents other than those that have been investigated so far, for example, the aromatics. Fundamental work on this aspect of the problem is still in its infancy.

Summarising these results, the measurements of the maintenance leaf of the bush does not appear to present itself as a rapid method for clonal selection, though relatively narrow leaves (high L/B ratio) seemed to be rich in polyphenols.

4. Further attempts to evolve a rapid chemical method for selection work.— The impression from the investigations so far carried out on the chemical basis for desirable quality may be summarised as follows :

(1) presence of high polyphenolic content;

(2) presence of a high oxidase content (this is probably always present in excess);

and (3) presence of a high theaflavin content in the made tea. There are probably other known or unknown constitutents to be considered.

Based on this impression a chemical method is being evolved for a rapid assessment of the quality of unknown bushes. For the time being, the method is being applied to TRI clones of known manufacturing properties, to test its validity.

The method involves the collection of about 20-25 flush points from the bush (less than 20 may be enough), mincing, fermentation for one hour, and extraction and determination of the theaflavin content. The method is very simple and rapid; about 40-50 bushes can be examined in a day with the minimum of staff. The number of bushes to be examined may be proportionately increased if the staff and equipment are also increased. It may be possible to adopt the method for tests in any estate.

Altogether 81 clones (TRI) were examined by this method and the results were found to be encouraging. The test eliminated *most* of the clones giving greenish liquoring characteristics. The test also indicated those clones which are rapid or good fermenters. Statistical analysis of the preliminary results showed that the four groups of the clones (namely A1, A2, B and C quality groups) were significantly different from one another in their theaflavin content. The chlorophyll content (and/or its degradation products) was correlated to the theaflavin content. Even taking allowance for this relationship, the mean theaflavin content was still significant ($<P0.01$). The following summary in Table 5 of the results so far obtained may be of interest.

TABLE 5.—*Composition of an extract of the fermented leaf (results expressed in arbitrary but comparative units)*

Constituents	Group A1 (4 clones)	Group A2 (17 clones)	Group B (15 clones)	Group C (14 clones)
Theaflavins (TF)	0·598	0·579	0·491	0·477
Chlorophyll and/or its degradation compounds (Chl)	0·270	0·255	0·238	0·247
Ratio TF/Chl	2·25	2·31	2·11	1·94
TF-Chl	0·328	0·323	0·260	0·229

It should be mentioned here that the results presented in Table 5, do not include the results of (a) all those clones which gave greenish liquoring characteristics and (b) those clones which appeared to be of doubtful grouping. Fourteen of the 81 clones examined appeared to be of doubtful grouping and these clones are being kindly re-examined by the Technologist.

The results of the clones showing greenish characteristics were compared with the rest of the clones examined. The results are presented in Table 6.

TABLE 6.—*Composition of an extract of the fermented leaf from clones showing normal and greenish liquoring properties*

Clones	Theaflavins (T.F.s	Chlorophyll and/ or its degradation compound (Chl)	Ratio TF/Chl	TF-Chl
Greenish liquors (17 clones)	0·469	0·263	1·77	0·206
Others (44 clones)	0·522	0·246	2·15	0·275

5. **Effect of N. P. K. Manurial treatment on the composition of the tea liquors and the tasters' valuations of the teas (miniature manufacture).**—This investigation was undertaken to find out how far the different manurial treatments would affect the composition of the tea liquors and the tasters' valuations for the liquoring properties. The results of only one set of 27 manufactures are ready; the inferences from the results will be drawn when more data become available. However, there are indications (not statistically significant) to show that (a) increasing doses of nitrogen application increased the caffeine and nitrogen content of the liquors while decreasing the soluble solids, the polyphenolic and the mineral constituents; but there was no appreciable change in the valuation ; (b) increasing doses of phosphorus increased the caffeine and the mineral constituents with practically no effect on valuation, and (c) the reaction to increasing doses of potassium appeared to be just the opposite to the effect of nitrogen.

6 **Acknowledgements.**—We are once again grateful to the tasters in Colombo for tasting our tea samples.

7. **Publications.**—Ramaswamy, M. S. (1961). A modified method for the determination of ammonia and nitrate in Ceylon tea soils. *Curr. Sci. 30*: 17-18.

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REPORT OF THE ENTOMOLOGIST FOR 1961

J. E. Cranham, B.A., D.I.C.

A. General.—There were no changes in personnel, but Mr Ranaweera was promoted to the Intermediate Grade. Estate visits numbered 225 and were mostly in connection with the heavy programme of dieldrin trials. There were 325 letters received and 416 letters sent out. I was on leave in Britain from July to October and visited several research stations; Mr D. J. W. Ranaweera acted for me during this time.

In September, when the team of Dr E. Judenko, Entomologist (Special Research on Shot-hole Borer), was disbanded, we took over the assessment of the six field trials in progress.

B. Shot-hole Borer.—1. Recommendations for chemical control.—Detailed provisional recommendations for the control of Shot-hole Borer (*Xyleborus fornicatus* Eichh.), by spraying the insecticide dieldrin at 1.5 lb. per acre just after pruning were published in the December 1961, Tea Quarterly (Cranham, 1961b). The basic recommendation is for one spray of six pints of 'Dieldrex 20' or of 'Dieldrex Extra' (Shell Company of Ceylon Ltd.) in 70-100 gallons of water per acre, applied on dry bush-frames as soon as possible after pruning and no later than bud-break. DDT is recommended for the control of the Tortrix side-effect (*see* section 6.2).

2. Large-scale dieldrin trials on estates.—With the co-operation of the Superintendents, the following dieldrin trials were continued: No. 1, Uva Ketawella 1956 new clearing: No. 2 Rothschild Group; No. 3, Delta Group; No. 4, Balangoda Group, Pinnawella No. 5 Field; No. 5, Uva Ketawella, No. 14A Field; No. 6, Imboolpittia 1957 and 1958 new clearings; No. 7, Choisy Estate; No. 8, Meddetenne Estate; No. 9, Meddecombra Group; No. 10, Uva Ketawella No. 8 Field; No. 11, Oodewella Estate; No. 12, Hantane Estate; No. 13, Endane Estate; No. 14, Balangoda Group, Pinnawella No. 1 Field; and No. 15, Endane Estate (Manurial trial). In addition, in September we took over from Dr Judenko three large-scale trials: 16/60 at Rye Estate, 17/60 at Queenstown and 18/60 at Demodera Group.

On ten of the trials started by us, it is possible to review the results after one year. These results have been described in detail in the March 1962 Tea Quarterly (Cranham, J.E., Danthanarayana, W. & Ranaweera, D. J. W., 1962). The average percentage reduction in infestation on the treated plots as compared with the untreated plots after one year was 74% and the average reduction in number of galleries was 67%. The percentage control was much better in those trials which had more infestation and galleries, after one year, on the untreated plots, notably in Trials Nos. 1, 4, 5 and 10, in which it was 100, 90, 93 and 76% for infestation and 99, 76, 75 and 73% for galleries. The over-all average figures quoted above are lowered by trials in which there was little infestation on the untreated plots after one year and also by two trials in each of which there was poor control on one of the dieldrin-sprayed plots. Four trials have run for a little longer, and on these the results remain good at 14 and 16 months after spraying.

These results are encouraging but we still have to wait and see whether the dieldrin spraying after pruning will prevent serious attack by the borer for a whole pruning cycle or whether it merely postpones the peak in numbers.

The trials are providing many useful data on the population dynamics of the borer on sprayed and unsprayed areas and on the reinfestation of the sprayed areas. It is too early to reach conclusions.

3. Dieldrin residues in made tea.—Results have been received from Shell International Chemical Company Ltd. (1961), on the analyses for dieldrin residues in samples of made tea from tipping leaf and the leaf of the first plucking, taken from plots sprayed at Uva Ketawella and Endane Estates. The results are given in Table 1. The dosage was 1.5 lb. dieldrin per acre. At Uva Ketawella, plot C was purposely sprayed one month after pruning to see if this increased residues. At Endane, where recovery is very much quicker, spraying was somewhat delayed because of rain, it was done when bud-break had commenced, and there were only four weeks between spraying and tipping.

TABLE 1.—*Dieldrin residues in made tea: Spraying details*

	Tea made from leaf of	Days between pruning and spraying	Days between spraying and plucking	Dieldrin residues in made tea p.p.m.
Uva Ketawella Plot A sprayed	Tipping	2	85	0·01
	1st plucking	2	135	0·01
Uva Ketawella Plot C sprayed	Tipping	32	55	0·02
	1st plucking	32	105*	0·02
Uva Ketawella Plot B Unsprayed	Tipping	87 days pruning-tipping		Nil
	1st plucking	137* days pruning-plucking		Nil
Endane sprayed	Tipping	16-21	28	0·05
Endane unsprayed	Tipping	49 days pruning-tipping		Nil

* delay caused by drought

These levels of dieldrin residues are extremely low and are well below the minimum tolerance of 0.1 p.p.m. set for dieldrin in many other foodstuffs in the U. S. A. and Canada. Even at Endane, where there were only four weeks between spraying and tipping, the tea contained only 0.05 p.p.m.

4. Yield trials.—Assessment has continued on the large scale trials at Rye (16/60), Demodera (18/60) and Queenstown (17/60), which were taken over from Dr Judenko in September. These three trials have been in plucking, after dieldrin spraying, for about one year. Over this period, the treated plots show an increase in yield over the untreated plots of 13% at Rye and at Queenstown and 11% at Demodera. The over-all average increase is significant at the 10% probability level, and there is a general upward trend in the percentage increase.

Assessment has also continued on the randomised block trials at Hantane (1/60), Kirimetiya (7/60) and Bandarapola (13/60). At Hantane, on the dieldrin sprayed plots as compared with the unsprayed, there has been a significant 26% increase in the period 0-21 months after spraying and a significant 50% increase in the period 18-21 months after spraying. There appears to be a downward trend now in the percentage increase; after a maximum of 72% in October, there were 40% in November and 28% in December.

At Kirimetiya there has been a significant increase of 19% in the period 0-21 months after spraying and also 19% in the period 18-21 months after spraying. There is no definite upward or downward trend apparent.

At Bandarapola, there has been a non-significant increase of 9% in the period 0-20 months after spraying, but a significant increase of 24% in the 16-20 month period, with an upward trend, month by month, to December (36%).

5. Persistent toxicity and mode of action of dieldrin.—At Kataboola Group, the replicated plot trial designed to study the persistence of dieldrin by artificial re-infestation of sprayed plots with heavily infested prunings was stopped in November. It had become clear that the re-infestation had not worked even on the untreated plots to an extent which intensive sampling could detect. Although this trial has failed to give us data on the persistence of dieldrin it has been useful (1) in suggesting other trial designs for this purpose and (2) in pointing to the need for greater knowledge of the chronology of adult life of the borer. It is probable, judging from work on other Scolytidae, that the adult females must go through a phase of dispersal by flight before making galleries and reproducing, and most of the beetles in the prunings would not be in the right phase to make galleries.

The results of the field trials generally suggest that the persistent toxicity of dieldrin is still being exerted 12-18 months after spraying. Previously it was reported that dieldrin brings about an initial 'massive' reduction of the beetles and their immature stages left in the bush frames after pruning. Although this is so, and has been confirmed in 1961, it would appear that the effectiveness of dieldrin by comparison with certain other insecticides is due to an extraordinarily persistent toxicity. How this effect is exerted in relation to the behaviour of the beetles, and the behaviour of the insecticide on or in the bush, are subjects for investigation.

6. Refinements of the control method.—One difficulty in carrying out effective spraying in practice is that it must be done on dry bark, and most pruning is necessarily done in wet seasons so as to aid the recovery of the bushes and prevent sun-scorch. In the wetter districts, such as Lower Dickoya, there are particularly few dry days in the pruning season. The method of spraying at 100 gallons per acre is also tedious, and particularly so on large bush frames. Low-volume application, by knapsack motor mist-blowers, is much more rapid and so better advantage can be taken of the available dry days. It is also much more convenient when the bush frames are large and awkward for high-volume spraying.

After preliminary experiments on coverage using fluorescent dyestuffs, a method of spraying was worked out using six pints of 'Dieldrex' in 10 gallons of water per acre applied by mist-blowers. The actual spraying time for one acre is about one hour for one machine; in high-volume spraying, four or more men with knapsack sprayers can spray one acre per day. This method of spraying has given good initial results and although the relative duration of effectiveness compared to high-volume spraying is still undetermined, it has been adopted routinely by certain estates.

Where a spray of lime, to kill moss on the bush frames, is required, it is possible that the lime and the dieldrin can be used together. This point is being investigated. Even when lime is not required for mossing, it is an excellent aid to supervision and might be used to advantage at a reduced rate for this purpose.

A detailed trial of randomised block design was started in June to compare low-volume and high-volume spraying, dieldrin with and without lime, and different dieldrin formulations.

Some consideration has also been given to other insecticides as possible alternatives to dieldrin. The major disadvantage of dieldrin is the Tortrix side-effect. The toxicity to mammals and birds is also fairly high and the

permissible tolerance for residues is very low. In recent work, B. H. C. and lindane formulations are the only materials which have received special consideration. 'Gammalin 20' (Imperial Chemical Industries (Export) Ltd.) gave poor results. 'Gamma-Cereclor', an experimental 26% wettable powder produced by the same company and designed to give better persistence, has given better, but as yet inconclusive, results.

7. Sampling methods.—Investigations on the sampling method were made on fields at Kataboola Group and on the plots of the Trial 1/60 at Hantane Estate. The chief comparison being made is between the original method of standard units which was developed and used by Dr Judenko and a method of taking less stringently selected sample units of branches. The data still have to be fully analysed but the facts suggest that the new method is likely to give more representative samples and be considerably more efficient generally on a 'man-hours of work' basis.

C. Tea Tortrix and Macrocentrus.—Tea Tortrix (*Homona coffearia* Nietn.) was prominent again in 1961. Natural outbreaks, mostly occurring above 4000 ft. were quite common in the dry weather from December 1960 to April 1961. Owing to the increase in the use of dieldrin for Shot-hole Borer control, outbreaks following dieldrin were also common although they were mostly controlled effectively by DDT.

1. Natural outbreaks. Previous work has shown that, in an outbreak, the numbers of Tortrix decline as the percentage parasitized by *Macrocentrus homonae* Nixon increases; by the time parasitism by *Macrocentrus* has risen to about 70% there were few Tortrix and there was very little fresh damage. In the dry season of 1961 it was common to find that Tortrix were still present in numbers, despite levels of parasitism as high as 70% to 80%. These attacks soon declined with the start of wet weather in April and May. The conception we have of this is that other factors, additional to *Macrocentrus*, are important in control. It would seem likely that a 'wilt' virus and a fungus disease, which are more active in wet weather, are the most important additional factors. Birds, notably the Ceylon Small White-Eye (*Zosterops palpebrosa egregia* Madarasz) and the Ceylon Hill White Eye (*Zosterops Ceylonsis* Holdsworth), are also of importance. In very dry weather, the proportion of Tortrix larvae not parasitized by *Macrocentrus* and not controlled by other factors can be sufficient to continue to produce numbers which can cause moderate damage.

Population studies of Tortrix in relation to natural control factors were continued on No. 13 Field, St. Coombs. The control of natural outbreaks with DDT was further studied and it was found that DDT did not interfere with the resumption of natural control by the *Macrocentrus* after spraying, so that there was no resurgence of Tortrix. DDT gave a high percentage kill of Tortrix and, when a few larvae were found 3-4 weeks after spraying the percentage of them parasitized was usually much higher than before spraying. The effect of spraying is therefore to leave the balance in favour of the parasite. Because of this, if Tortrix is causing damage, there is no reason to hesitate about using DDT because of fear of damaging *Macrocentrus*.

2. Outbreaks following dieldrin spraying.—Observations and sometimes counts were carried out or continued on seventeen large-scale trials (Trials Nos. 2-14 and four other trials at Kataboola Group, and Attampettia, Kirimetiya and Aislaby estates). This work has been reported in detail in the March, 1962, Tea Quarterly. Recommendations for the use of DDT were made in detail in the December 1961 Tea Quarterly (Cranham 1961b).

To summarise, Tortrix caused moderately bad damage on seven out of fourteen trials on the plots sprayed with 1.5 lb. dieldrin per acre. The attacks were largely confined to the dieldrin-sprayed areas. One spray of DDT

emulsion (2 lb. DDT per acre) to half of each dieldrin-sprayed plot failed to maintain good control of Tortrix in these trials because of rapid dispersal of Tortrix. When sprayed on the whole of a dieldrin-sprayed field or plot, DDT has given good control. The DDT did not appear to interfere with the re-establishment of *Macrocentrus homonae*. Where Tortrix outbreaks occurred, the time taken for the parasite to re-establish control of the Tortrix varied between three and six months in the different trials.

At worst, Tortrix attack, if allowed to go unchecked by DDT spraying, can be so bad as to result in very bad defoliation and a loss of crop large enough to counter-balance the possible yield increase to be obtained from shot-hole-borer control. This is known to have occurred on three estates out of about a hundred which have experimented with dieldrin spraying in 1960 and 1961. All three estates have sprayed other fields with dieldrin with negligible damage by Tortrix. If a large part of an estate is to be sprayed within a few months, the factors influencing the parasite are likely to be complex. Only observations on practical usage can determine the position. So far it is apparent that there are a few estates in which the immigration and build-up of the parasite on sprayed fields has been much slower than on estates in general, thus creating a more difficult problem in Tortrix control, but there is no reason to think that these estates are permanently in this position. At present the factors which may operate can only be guessed at, e.g., isolation of the sprayed area from other tea by grassland; a very low initial availability of the parasite; or a heavy mortality of the parasite caused by extensive spraying of dieldrin; natural enemies or climatic factors which may reduce the normal rate of increase.

It would seem wise to limit dieldrin spraying to not more than half the acreage of an estate in any one year and not more than a quarter of the acreage in any one period of six months.

No other side-effects of dieldrin that are comparable to that of Tea Tortrix occurred in these trials. Tortrix larvae and the larvae of some unidentified Lepidoptera have been noted also defoliating *Albizzia falcata* (L.) Back. used as a shade tree above the tea. The incidence of a few other pests requires investigation.

D. Mites.—1. The effect of insecticides on mite numbers.—On the Gonomatava trial, sprayed in April, assessment of the numbers of Scarlet Mite and Red Spider Mite continued monthly until December. Compared with the unsprayed plots, there were significantly more Scarlet Mites on the DDT plots from May to August (3 times more at peak) and significantly more Red Spider from May to July (3-4 times more) (See Tables 2 and 3). Together with reports from a few estates, this leaves no doubt that DDT can increase the number of both these species of mites. However, it should be noted that in the 17 estates dieldrin trials assessed by us there were no appreciable outbreaks of either mite species on the DDT-sprayed plots.

TABLE 2.—*The effect of DDT and dieldrin on Scarlet Mite*

Treatment	Adjusted mean* number of Scarlet Mites per 100 leaves (400 counted)				
	Precount April	May/ June	July/ Aug.	Sept./ Oct.	Nov./ Dec.
Untreated	562	521	506	455	151
Dieldrin 1·5 lb per acre (one spray)	575	378	216	93	51
DDT, 2 lb per acre (one spray)	488	891	1671	537	112

* antilog of mean log number

TABLE 3.—*The effect of DDT and dieldrin on Red Spider Mite*

Treatment	Adjusted mean number of Red Spider Mites per 100 leaves (400 counted)			
	Precount April	May	June	July
Untreated	15	9	40	110
Dieldrin, 1·5 lb per acre	9	11	44	61
DDT, 2 lb per acre	5	42	180	343

On the dieldrin-sprayed plots (foliage sprayed and crop discarded) there were significantly less Scarlet Mite (but not Red Spider) from May up to December, and the difference still continues. There were 3-4 times less than on the untreated control plots from September to December. Dieldrin is not usually considered an acaricide but it appears to be fairly effective (though impracticable) against Scarlet Mite. It does not follow from this that when dieldrin is applied to bush frames after pruning it will have any effect on the numbers of Scarlet Mite. It does, however, free dieldrin (though not DDT) from any charge of increasing the numbers of these mites.

It has not so far been possible to reach any conclusions on the effect of dieldrin and DDT on Yellow Mite.

2. The effect of copper fungicides on mite numbers.—It was reported previously (Cranham, 1961a) that spraying with copper oxide and copper oxychloride wettable powders for blister-blight control could increase the numbers of Scarlet Mites (*Brevipalpus* spp.), and that a colloidal copper formulation had given no increase in numbers over the control. Hence it was desirable to see whether this effect was intensified when larger plots were sprayed and whether it occurred with other mite species on tea. Since copper fungicides must be used for blister-blight control, the essential practical point is whether there is an advantage to be gained from using colloidal copper formulations as opposed to wettable powders of copper oxide and copper oxychloride.

A further trial was therefore started at Gonomatava Estate, Haputale, in November 1960 and continued through 1961. The field used was pruned in January 1960 and was already showing some Scarlet Mite attack when the trial was started. It is a field prone to mite attacks. Plots of one acre size were used, since it was felt that with plots of 100-200 bushes, as used previously, the differences may have been somewhat obscured by mite dispersal especially with Yellow Mite (*Hemitarsonemus latus* Banks) which is spread rapidly by wind.

Because of the developing interest in mist-blowing copper fungicides, both normal volume (N. V.) spraying at 15 gallons of water per acre by knapsack sprayers, and low-volume (L. V.) spraying at 2 gallons per acre by mist-blower, were used.

The treatments used were a proprietary 50% copper oxide wettable powder and a 27% colloidal copper formulation, each of which was used at (1) 4 oz in 2 gal. per acre by mist-blower ; (2) 4 oz in 15 gal. per acre by knapsack sprayers; (3) 8 oz in 2 gal. per acre by mist-blower and (4) 8 oz in 15 gal. per acre by knapsack sprayers. There were thus eight one-acre plots and an untreated control plot alongside. Spraying was done in the north-east monsoon from 1.11.60 to 6.4. 61. Mite counts were made initially on 1.11.60 and at intervals from March 1961 when the mites would usually increase in the dry season.

Blister-blight infection was assessed on twelve occasions and the results are summarised in Table 4. There were only five occasions when the untreated plots had 35% infection or more. No treated plot exceeded 35% infection at any time but the copper oxide wettable powder gave slightly better control than the colloidal copper formulation. There was no over-all difference between the results from normal-volume and low-volume spraying. The difference in control obtained from the two dosages, 4 oz. and 8 oz, was not large.

TABLE 4.—*Summary of blister-blight infection on Gonomatava trial*

	Percentage infection (Avg. of 4 plots)						% infection, untreated control plot
	Copper oxide	Colloidal Copper	N.V.	L.V.	4 oz	8 oz	
Avg. of all 12 counts	7·2	11·6	9·5	9·7	11·7	7·6	31·2
Avg. of 5 counts when untreated 35% infection	9·0	14·9	12·7	11·6	14·6	9·8	52·1

The numbers of Scarlet Mite occurring were quite small, and instead of increasing during the dry season from March to September they declined somewhat (Table 5). There was nevertheless on average about twice as many mites on the copper oxide plots as on the colloidal copper plots. There was no appreciable difference between N.V. and H.V. plots or between the two dosages used.

Table 5

The effect of copper fungicides on the numbers of Scarlet Mite and Red Spider Mite

	Averages for 4 plots, Mites per 100 leaves (400 counted) on					Avg. after treatment
	17·3·61	23·6·61	24·7·61	31·8·61	27·9·61	
Scarlet Mite Copper oxide W. P.	338	49	57	234	129	162
Colloidal Copper	117	41	74	95	65	78
Red Spider Mite Copper oxide W. P.	20	79	530	916	541	453
Colloidal Copper	128	47	262	348	281	213

The numbers of Red Spider Mite (*Oligonychus coffeae* Nietn.) increased on all plots from March to September and there were on average about twice as many on the copper oxide plots as on the colloidal copper plots (Table 5). As with Scarlet Mite, there was no appreciable difference between the two volumes or the two dosages. Comparison of the treated plots (four of each treatment) with the one untreated plot is not valid; since it was not desirable to leave four acres of tea exposed to blister-blight infection, this one untreated plot was all that could be left. It was used only as a rough guide to blister-blight infection.

The differences obtained are slightly less than those obtained in the 1960 experiment and again, from a practical point of view, do not appear to be very meaningful. The data provide evidence of this effect occurring with Red Spider where evidence existed before only for Scarlet Mite, and the numbers of Red Spider at least reached the level of a mild outbreak. The numbers of Scarlet Mite were very low and declined even further despite copper spraying.

It is of some interest to note that although copper spraying ceased in April the differences apparent in March were shown also months later in August and September. There was no difference between the results from the two dosages of copper and this again suggests that it is not the quantity of copper that matters. The result supports the belief that the use of copper fungicides is only one factor conducive to a build-up of mites and it does not appear to be an important one. There is no evidence here that there would be a marked advantage in using colloidal copper formulations as opposed to wettable powders of copper oxide.

No Yellow Mite occurred in this trial and we still have no proof of an effect on this species.

3. **Yield trial (Gonomatava Estate).**—This trial was started in 1960 to study the effect on the yield of tea of controlling mites with acaricides. Pre-assessment of the yield was kindly carried out for one year by the estate. In June 1961, when mites started to build up, Kelthane was sprayed on half the plots at the high dosage rate of 8 lb. per acre in order to accentuate differences in mite numbers between the sprayed and the unsprayed plots. After spraying, there was a significant 78% increase in crop on the sprayed plots as compared with the unsprayed plots (=100%), for the month of July. This increase is believed to have been due to the control of Yellow Mite on the flush. The numbers of Scarlet Mite and Red Spider Mite, which were never high, declined on the unsprayed plots as well as on the sprayed plots after July. By August, Yellow Mite had cleared up on all plots and there was very little difference in the yields from August to December.

4. **Population studies.**—Periodic sampling of Scarlet Mite and Red Spider Mite were carried out on plots at Gonomatava and Kirimetiya estates, and weather records were maintained. It is too soon to review results. It may be mentioned that data from Kirimetiya show a greater number of Red Spider Mite on unshaded plots as compared with shaded plots. This difference is not shown in the Scarlet Mite counts.

E. White Grubs.—Work continued on the larvae of chafer beetles associated with tea. Early in 1961, laboratory rearing gave ultimate proof of the identity of the larva *Holotrichia disparillis* Arr. which is the most injurious species in new clearings and the larvae of which are highly resistant to aldrin (Cranham, 1961a). The larvae of *Anomala mundissima* Walk. and *A. superflua* Arr. were also reared through to the adult stage. The larva of *Leucopholis pinguis* Burm. is virtually certain on the character of size alone. Identification and the study of the larvae of other species continued.

Work on adult emergence periods, studied by light trapping, was carried out at High Forest, Kandapola, and at St. Coombs. An extensive search was carried out in up-country estates in June and July for the occurrence of *H. disparillis* in new clearings. The occurrence in new clearings appeared to be even more restricted than in the previous year. Sites for trials were eventually obtained at High Forest Estate at Mooloya Estate and, late in the year, at Waltrim Group. We have not yet succeeded in finding a satisfactory chemical control for *Holotrichia disparillis*. Several chemicals have been tried out at high dosages, as follows :—

Formulation	*Dose per acre of active insecticide*
'Gammexane 26% W.P.'	7½ lb. Gamma B.H.C.
DDT 50% W.P.	20 lb. DDT
'Dipterex 80% W.P.'	6 lb.
'Intox 8'	8 lb. Chlordane
'Sevin 85% W.P.'	4 lb. Sevin
'Aldrex 2'	4 lb. Aldrin
'Dieldrex 20'	2 lb. Dieldrin

The costs of these treatments range from about Rs. 40/- to Rs. 100/- per acre for the chemical. Treatments at Mooloya (on bare ground before planting) and at High Forest (February 1961 new clearing) were watered on to the soil surface in 200 gallons of water per acre and worked into the top 3″ of soil with scrapers. The maximum reduction in numbers of *Holotrichia* was obtained from B. H. C.—about 60% six weeks after treatment. At Mooloya, a *Microtrichia* sp. also occurred and B. H. C. gave 75% reduction of this species six weeks after spraying. Although there were nearly as many grubs per square yard at High Forest as in the previous years, the losses of plants were less, and generally insufficient to cause great concern. It would thus appear that, for unknown reasons, not only the occurrence, but also the liability to damage, is subject to great variation from year to year.

In separate plots at Mooloya, D-D was injected in the bare ground at 25 gallons per acre, and this gave the best kill of *Holotrichia*—87% after six weeks. This treatment is of course only practicable before planting and is costly. Other fumigants which can be used around living tea, such as Nemagon, would be worth trying.

Because it would seem that an important factor is that of obtaining really good distribution of a toxicant in the top 6″ of soil, efforts in the Waltrim trial (started in November) were concentrated upon applying heavy doses just around the plants, by injection and by surface treatment, in the hope of minimising damage to the plants rather than trying to achieve a high percentage kill of grubs. B.H.C. and 'Dipterex', the most promising insecticides in the other two trials, were included and also the new Shell insecticide 'Telodrin' and the systemic insecticide 'Dimecron'. Assessment of plant losses has not so far shown any marked difference between the treated and the control plots.

F. General.—1. Mist-blowers.—In view of the interest in knapsack motorised mist-blowers developing amongst planters, a working party was organised at Radella Club on April 14th to discuss and clarify points about this development. Under the Chairmanship of the Director, T. R. I., the meeting was organised by myself and Mr A. L. Elias, and Dr D. Mulder also addressed the meeting. About 50 people attended, which included representatives of the planting community, commercial firms selling the machines, and T. R.I. staff. The report of the meeting was published in the December Tea Quarterly (Cranham 1961c).

Work continued on mist-blowing dieldrin for control of Shot-hole Borer, DDT for Tortrix and other pests, and sulphur and Kelthane for Yellow Mite control.

2. Insecticide residues in made tea.—Analyses of DDT residues have been completed by the Tropical Products Institute, London, and a joint report has been submitted to the Scientific sub-committee on the use of poisonous substances in Agriculture and Food Storage for their opinion.

3. Advisory work.—Apart from liaison with Advisory Division, some attention has been given to certain pests of tea and shade trees which can cause severe damage locally. These include scale insects, Red Borer (*Zeuzera coffeae*

Nietn.), and Albizzia Bark-eating Borer (*Indarbela quadrinotata* Walk.). Unfortunately, these and other insect pests which cause damage locally cannot be tackled properly until the present volume of work on Shot-hole Borer has been reduced.

G. Publications.—(also quoted as references in the text).

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H. Acknowledgments.—A great deal of help from the Superintendents of estates is most gratefully acknowledged. This applies, as in 1960, to the estates which are carrying out dieldrin trials, and we also wish to thank the Superintendents of Gonomatava and Kirimetiya Estates for assistance in work on mites, and the Superintendents of High Forest, Mooloya and Waltrim Estate for work on White Grubs.

Shell International Chemical Company Ltd., have kindly carried out work on dieldrin residues, and the Tropical Products Institute, London, have done similar work on DDT residues.

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REPORT OF THE ENTOMOLOGIST (SPECIAL RESEARCH ON SHOT-HOLE BORER) FOR 1961

E. Judenko, Ph. D.

A. General.—The team, which was disbanded on 15th September 1961, consisted of two Technical Assistants, four Field Attendants, a driver and myself.

The laboratory and headquarters of the staff was at Kandy from January, 1961. The field work was conducted in the Kandy, Uva, and Balangoda areas.

B. Dieldrin spraying of the basal parts of tea bushes soon after pruning.—Six experiments were begun in 1960 (Judenko 1961) and they are listed in Table 1.

TABLE 1.—*Information about the dieldrin-spraying experiments*

Experiment No.	Estate	Experimental area in acres	Dieldrin dosage per acre*	Date sprayed 1960	Age in years
1/60	Hantane	4·8	5·1	29/2—4/3	33
7/60	Kirimetiya	1·28	2·3	15/3	*ca.* 20
13/60	Bandarapola	1·28	2·8	22/4	40
16/60	Rye	35·38	1·6	10/9—16/9	11
17/60	Queenstown	37·92	1.7	22/9—4/10	38
18/60	Demodera	36·7**	1·5	12/10—17/10	51

*On the basis of 2500 bushes per acre, except in experiment No. 16/60, where the number was 3400 per cre.

**In Judenko (1961), instead of this figure an incorrect one of 27·15 was quoted.

1. Influence of dieldrin spraying on shot-hole-borer populations.—At Hantane, the live adults in the sprayed area numbered only 10% of those in the control 18 months after spraying, and at Kirimetiya the relation was the same 15 months after spraying. But at Bandarapola, owing to the very small number of live adults in the control, no conclusions could be drawn. Considerable reductions in the number of live inmates were indicated in the other three experiments within 10-11 months after spraying.

2. Influence of dieldrin on the numbers of galleries made by Shot-hole Borer.—At 18 months after spraying the numbers of galleries were 22% at Hantane, and 52% at Kirimetiya, compared with the unsprayed controls. No conclusion could be drawn from Experiment No. 13/60 at Bandarapola. owing to the rather small number of galleries on control plots.

3. Influence of dieldrin spraying on the production of new wood of tea bushes.—In the first three experiments the clearest results were obtained in the Hantane experiment. On treated plots at 18 months after spraying, 58% of the sample units had young bark but on the untreated plots only 33% had. There is, however, some difficulty here in that the bark seems to age more

rapidly in infested new wood. In Experiments No. 16/60, 17/60 and 18/60, only standard units that had old bark were examined, so no conclusions regarding the influence of dieldrin spraying on the production of new wood could be drawn from them.

4. Influence of dieldrin spraying on the weight of the yield of green leaf.—No significant increase in the weight of green leaf took place within 12 months after spraying in the Hantane experiment; but an increase of 41% of the yield had occurred by 15 months after spraying and an increase of 21% by 18 months after spraying.

In experiment No. 7/60, the increase in the weight of green leaf in the first 11 months after spraying was 15% and in the first 18 months was 16%. A significant increase in the yield of green leaf in the Bandarapola experiment took place only during the period from 12—16 months after spraying, and the weight of green leaf on treated plots was 8.5% more than in control plots.

5. Influence of dieldrin spraying on taint and the liquoring properties of the manufactured tea.—These points were investigated for the first time in 1960 (Judenko 1961) and for the second time in 1961, using tea obtained from the pluckings carried out on 31st August and 7th and 14th of September of the Hantane experiments. In these three plucking rounds, the treated plots yielded 52%, 75% and 60% more green leaf than the untreated plots. The batches of plucked leaf from the treated and control plots of these three pluckings were manufactured by the Technologist of the T.R.I. who reported that the made teas were free from taint and showed no difference from the control as regards liquoring properties of the manufactured teas.

6. Influence of dieldrin spraying on dieldrin residues in made tea.—This point was investigated for the first time in 1960 (Judenko 1961) for Experiment No. 1/60 only. In 1961 another experiment (No. 1/61) was carried out at Hantane, applying 1.6 lb. of active ingredient of dieldrin per acre (3400 bushes). Pruning was carried out from 14th to 16th March 1961, and the dieldrin was sprayed on the dry bush frames to a height of 12 in. above the ground level on 16th and 17th March. The first tipping was carried out on 24th May, and the first plucking on 23rd June. Leaf batches from treated and control areas, from these first tippings, and pluckings, were manufactured by the Technologist of T.R.I. and then samples were sent to the Shell International Chemical Company Ltd. in England for examination for dieldrin residue. No residues were found, employing the gas-liquid chromatography technique of analysis. (Shell I.C.C. Ltd., 1961).

7. **Influence of dieldrin spraying on tortricid caterpillars.**—In Experiment No. 17/60, dieldrin spraying caused an outbreak of tortricid caterpillars within 5 months after spraying and in a further 4-5 months the attack almost faded out. The counts of caterpillars were carried out monthly and the peak number found on the plots sprayed with dieldrin was 5076 caterpillars per 100 tea bushes, in February 1961.

In Experiment No. 18/60, an outbreak of caterpillars also appeared about 5 months after dieldrin spraying, and the peak number of caterpillars was 557 caterpillars per 100 bushes, found in March 1961. In both estates about 90% of the caterpillars were Tea Tortrix (*Homona coffearia*, Nietn.) and the remaining 10% were Tea leaf Roller (*Gracillaria theivora* Wlsm., Gracillariidae.)

The numbers of tortricid caterpillars found in the four remaining experiments were very small.

8. Influence of DDT spraying on tortricid caterpillars.—As was mentioned previously (Judenko 1961), in Experiments Nos. 16/60. 17/60 and 18/60, each dieldrin-sprayed plot was roughly divided into two halves, one of which was

sprayed with DDT on the foliage to combat Tea Tortrix. The following amounts of active DDT per acre were used in these three experiments: Rye-1.9 lb.; Queenstown and Demodera—1.8 lb. At Queenstown and Demodera there were indications that DDT spraying caused considerable reduction in the number of Tortrix caterpillars.

9. Investigations on the re-infestation of dieldrin-sprayed plots by Shot-hole Borer.—These investigations were carried out on the experimental areas at Rye, Queenstown, and Demodera, but owing to the very small number of live Shot-hole Borers present, no definite conclusions could be reached.

10. Relationship between the individual factors.—Analysis of Experiment No. 1/60 and, in part, Experiment No. 7/60, enables us to draw the following conclusions regarding the relationships between the individual factors within the first 18 months after dieldrin spraying. A positive correlation was found between the numbers of live adults and the total number of galleries made by Shot-hole Borer, and also a positive correlation between the numbers of standard units with young bark and the yield of green leaf.

There were inverse correlations between the total number of galleries and the yield of tea, and also between the number of live adults and the percentage of standard units with young bark.

Publications and References

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REPORT OF THE NEMATOLOGIST FOR 1961

M. T. Hutchinson, Ph. D.

Staff.—The staff remained the same as reported for 1960.

General.—During the year, 115 visits were made to estates; 183 letters were received, and 192 were sent.

Projects.—(a) Resistance and tolerance to the Meadow Nematode.—The second series of pot tests, wherein 9 clones are being tested for their resistance to 25 collections of the Meadow Nematode, (*Pratylenchus loosi*) is now being evaluated. The nematodes were present in soils taken from small areas of infested mature tea, on 25 different estates. Clone DT 95 has made the best average growth over a period of 27 weeks, and DK 8 the poorest. Clones DK 1, DT 1, DK 10, TRI 2025, TRI 2024, and TRI 2135 have made good to poor growth, in the order given. Total growth of all clones varied greatly in each of the 25 soils. In some soils, the plants hardly made any growth (Figure 1) and in others, growth was good (Figure 2). However, in no infested soil was growth equal to that in soil obtained from under Guatemala grass (Figure 3), which was fumigated to kill any nematodes present. Reasons for the great differences in growth among the 25 soils could involve many factors, such as soil aeration, soil microbiology and inherent soil fertility, in addition to the number of nematodes present and whether or not nematodes from one locality are more pathogenic to tea plants than those obtained from another locality. However, although a reason cannot be assigned to this varied growth in different soils, it would appear that estates having Meadow Nematode would be better advised to replant rather than to resupply infested areas.

The one year trial of 55 clones at Mooloya Estate has been completed, and on the basis of shoot and root growth, and infestation by Meadow Nematode, 11 clones have been selected as worthy of further testing. In descending order of performance, these are: M 116, 146, 208, 114, 33, 57, 21, 241, 209, 110, and 16. Growth of all these clones equalled or surpassed that of clones DT 95 and K 145, which give consistently good growth in infested areas. Clones M116, 146, and 208 were particularly outstanding, and this result is in contrast to that obtained in the first pot trial at St. Coombs, wherein M 116 and M 208 showed poor growth when infested in comparison with 66 other clones under test. Other notable differences in the results of these two trials include clone M 111, which was the poorest of all in the pot trial, but grew rather well at Mooloya; and clone M 7, which grew rather well in the pot trial, and was one of the poorest at Mooloya.

The above differences in result are of such a magnitude that the differences in method between the two trials should be set forth in more detail. The St. Coombs trial was conducted in square cement pots containing 6 inches rubble, overlaid by $\frac{1}{2}$ cu. ft of soil. The duration of the trial was 5 years, although the Mooloya clones tested were introduced into the trial one year after the beginning and hence had only 4 years' testing. Five pots of each clone were infested and five were uninfested. The pots were not randomized. The soil was presumably the same for all pots, and the nematodes used were obtained from Eildon Hall and Diyanilakele estates. Subsequent infestation of apparently

Plate 1.—Poor growth of plants in tea soil, infested with nematodes. The five clones growing in each pot are; DT 1, DK 8, DK 10, K 145, TRI 2024.

Plate 2.—Good growth of plants in tea soil, infested with nematodes. Clones are the same as in Plate 1.

Plate 3.—Very good growth of plants in Guatemala grass soil, fumigated to eliminate nematodes. Clones are the same as in Plate 1.

resistant clones was made with nematodes from St. Coombs Estate. Performance was measured both by visual appearance of the shoots and by weighing the prunings from each plant.

At Mooloya, the trial was conducted in small, randomized plots, each containing 10 replications of 10 clones planted at intervals of one foot. Six of these plots were laid out adjacent to one another in two rows of three. Clone TRI 2024 was present in each plot. The same trial was conducted at each of 2 elevations: 4000 ft and 5000 ft. The soil at 4000 ft. was gravelly and tended to bake, whereas that at 5000 ft. had a very fine tilth. Performance was measured by visual appearance of shoots and roots.

Major differences between the 2 trials therefore include: soil type, and presumably associated microflora and microfauna, source of nematodes, climate, duration, method of measurement of growth, the use of both infested and uninfested plants, and the differences inherent in the use of pots versus field plots.

In evaluation of clones for tolerance of Meadow Nematode, we are therefore faced with the problem of providing reasonably standard conditions of testing that will simulate growth in the field at many locations. As a first step toward this goal, we have constructed 4 separate nursery beds and filled them with a mixture of infested soils from 25 estates. Half of these beds are fumigated, and half are not fumigated. Plants of clones to be tested are paired, as between fumigated and unfumigated beds, and are randomized within a border of plants of clone TRI 2024. Twelve clones, including TRI 2024 and DT 95, are now under test. Growth rates, as determined by measuring leaf areas, are being recorded at regular intervals for each plant. The test will continue for one year, after which all plants will be weighed and examined for nematodes in the roots. Clones performing well in the current test, and in subsequent tests under similar conditions, will then be tested in field trials at other locations.

In the Mooloya trial, Meadow Nematodes were found in the roots of all plants, indicating that no clone tested was immune. However, the numbers present in the roots of different clones varied considerably. Table 1 shows that among clones having similar root and top growth, DT 95 supported very few nematodes.

TABLE 1.—*Relative resistance of clones, as shown in the trial at Mooloya Estate*

Clone(1)	Nematodes in roots(2)
DT 95	986
M 17	2286
K 145	5325
M 35	15871

(1) *clones with very similar growth of both root and top.*

(2) *average number of nematodes per plant in roots of 8 plants.*

Because of this difference in resistance, nematodes from roots of different clones were examined to determine whether or not the percentage of larvae or the sex ratio of adult nematodes differed among clones. For example, a low percentage of females might help to explain why a clone was resistant. However, examination of a total of 6500 *Pratylenchus loosi* from the roots of 7 clones (TRI 2024, 2142, and 2145, K 145, M 243, DK 8, and DT 95) showed an average of 57 per cent. larvae, with no significant differences among clones. Examination of a total of 3062 adult *P. loosi* from the roots of these same clones showed an average of 59 per cent. females, with no significant differences among clones.

In all current tests for resistance of clones, the method of evaluation for Meadow Nematode has been changed from examination of soil to examination of roots. Comparative tests have shown that from 8 to 25 times more nematodes can be recovered from each gram of root than from 100 grams of soil (10 tests). The much larger number of nematodes obtained from a unit weight of roots than from a unit weight of soil is understandable, in view of the fact that the Meadow Nematode is an endoparasite and therefore is found only incidentally in soil. Indeed, it is conceivable that where previous examination of soil has shown negative results, examination of the roots would have demonstrated the nematodes to be present. Further evaluation showed that a modification of the technique for root examination (blended roots poured directly upon a special paper filter, rather than upon a fine-meshed screen) resulted in 3 times as many nematodes being recovered (4 tests).

Laboratory tests of clones, to determine various ways in which they are resistant, have been continued. Of 23 clones tested during the year, 2 clones (M 208 and TRI 2118) showed no nematodes or eggs in the roots at the end of 5 weeks' testing, whereas other clones, infested at the same time, supported large numbers of both. Clones DK 8, GL 48, KW 16/3, and K 150 were clones in which some females left the roots after depositing eggs. Further tests are being planned, with the young plants growing in polythene bags rather than in Petri dishes.

Selections of possibly resistant or tolerant bushes have been made from infested areas on Derryclare and Wootton estates. In each case, the Superintendent initially selected about 100 bushes, which were then carefully re-selected by Mr F. H. Kehl and members of the Nematology Division, to eliminate those bushes bordering roads and drains, those of poor bush type, and those too susceptible to Blister Blight. The remaining bushes at Derryclare were tipped, and the ones that produced the highest tipping weights were test-plucked for

20 rounds. Four plants with the highest yield per square foot of plucking surface were then chosen, and these will be tested for resistance to and tolerance of Meadow Nematode at the Institute. The selection at Wootton is not yet complete.

A preliminary survey has been made to determine the number of mother bushes available of clones that are known to be resistant and/or tolerant, or are being tested in this regard. Where the total number of mother bushes already available at St. Coombs and other estates is less than 100 per clone, additional plants are being propagated at the Institute. Plants of 9 such clones will be set out in the field in June.

(b) Influence of organic matter on populations of Meadow Nematode, and growth of plants.—The last 4 months' evaluation of the trials at Ferham Estate showed results similar to the first 8 months, i.e. no appreciable effect of compost on populations of Meadow Nematode. Research with compost is being discontinued because other lines of work appear to be more promising.

(c) Influence of marigold on survival of Meadow Nematode and growth of tea plants.—The preliminary test of ability of marigolds to kill meadow nematodes in soil was completed. The nematodes, contained in soil, were introduced into pots containing marigold plants in different stages of growth. After one month, the marigolds were lopped at ground level and one plant of clone TRI 2024 was planted in each pot. After 8 months, counts of nematodes in the tea roots showed that exposure to marigolds had produced a much greater reduction in numbers of nematodes than had fallowing the soil for a similar time (Table 2).

TABLE 2.—*Effect of marigold at different stages of growth in killing meadow nematodes introduced into soil* (1)

Treatment (2)	Nematodes per gram of tea roots Replicates			
	1	2	3	Total
Marigold, flowering	67	817	133	1017
Marigold, lopped before flowering	166	117	67	350
Marigold, 12 weeks	33	0	33	66
Marigold, 8 weeks	267	267	150	684
Marigold, 4 weeks	17	67	183	267
Untreated, (fallow)	950	1700	1550	4200

(1) *Using uninfested plants of clone TRI 2024 subsequently grown for 8 months as an indicator crop to determine survival of infective nematodes.*

(2) *Age and condition of marigolds when the nematodes were introduced by means of infested soil. The nematodes were exposed to the marigold plants, and to fallowing, for a period of one month.*

Another test in pots showed that seeding marigold around infested tea, and allowing it to come into flower, greatly reduced the numbers of nematodes present in the soil, but had no effect on those inside the roots (Table 3).

TABLE 3.—*Effect of marigold in reducing the numbers of nematodes present in soil and in adjacent tea roots*

Treatment	Nematodes per gram of tea root	Nematodes per gram of Marigold root	Nematodes per 100 gram of soil
tea with m rigold	1804(2)	0(1)	3 ·4(3)
tea without marigold	1078(1)	—	34 ·0(4)

(1) *average 8 replicates*

(2) *average 5 replicates (3 plants died)*

(3) *average 6 replicates* } *error in sampling*

(4) *average 4 replicates* }

Laboratory tests, using recently germinated marigolds growing in Petri dishes, showed that the Meadow Nematode will enter the marigold roots and deposit a few eggs, but is then killed within 7 to 10 days. However, roots of older marigold plants growing in infested soil remain apparently free of nematodes (Table 3). A possible explanation is that the amount of toxic substances produced by the older roots is so great that the nematodes are killed while attempting entry.

A field trial was initiated at Derryclare Estate, to determine whether or not the planting of marigold in infested tea after pruning increases the yield of tea. Marigolds are being compared with Nemagon, injected at a rate of 10 gallons per acre, and no treatment. Bushes were test-plucked for 20 weeks before pruning, and sampling showed that all plots were infested with Meadow Nematode. The trial is proceeding nicely.

All work with marigold is being intensified.

(d) Chemicals to kill Meadow Nematodes in tea roots.—Nemagon emulsion concentrate was applied at a rate of 2.7 gallons per acre actual Nemagon to infested plants of clone TRI 2024 growing in pots. This treatment gave a significant degree of control when the plants were examined after 6 months. Treatment of infested plants with emulsion concentrates of parathion, Diazinon, and VC-13 and with a 2 per cent. granular formulation of Compound 18-133 (American Cyanamid Company) produced lesser reductions in the number of nematodes in the roots (Table 4). Nemagon at 4 dosage levels, is being retested in a new trial that includes the organo-phosphate insecticide Dimecron.

TABLE 4.—*Effect of chemicals applied to soil on the numbers of meadow nematodes in roots of infested tea growing in pots* (1)

Treatment	Dosage per 8″ pot (2)	Nematodes per gram root (3)
Parathion (20 EC)	0·1 c.c.	5801
	0·2 c.c.	4084
Nemagon (20 EC)	0·3 c.c.	818
18—133 (2% granules)	0·3 grm.	4766
	0·6 ,,	4617
	1·2 ,,	4583
	2·4 ,,	4216
	4·8 ,,	3433
VC-13 (75 EC)	0·5 c.c.	1967
Diazinon (60 EC)	0·7 c.c.	3533
	2·1 c.c.	2351
Control	Untreated	5666

(1) *clone* T.R.I. *777*
(2) *single application*
(3) *total for 7 plants after 6 months exposure.*

(e) Survey for distribution of Meadow Nematode.—No soil samples were received from estates during the year, and a summary of this work for previous years is therefore presented. We have records of samples from a total of 416 estates. Some of these have only been sampled once; a few as many as 100 times. The highest number of nematodes recovered from any 100-gram soil sample has been listed for each estate. A number of nematodes in excess of 125 per 100 gram of soil is arbitrarily taken as an indication of a 'heavy' infestation, since all estates from which such numbers have been recovered show evidence of severe injury by Meadow Nematodes. A number of nematodes ranging from 26 to 125 is considered to be a moderate infestation, and many of the estates from which these numbers have been recovered show evidence of injury. Estates from which 6 to 25 nematodes have been recovered have not shown evidence of injury, and those from which only 1 to 5 nematodes have

been recovered are considered to be very lightly infested. On this basis, estates at different elevations and in different planting districts can be compared with regard to Meadow Nematodes recovered from their soils.

TABLE 5.—*Meadow Nematodes recovered from soil*(1) *of estates at different elevations*

Number of nematodes recovered from 100 grm of soil	Approx. elevation and number of estates					
	4000 ft and above		2000-4000 ft.		2000 ft. and below	
	No.	estates %	No.	estates %	No.	estates %
above 125	18	8	1	1	0	0
26-125	35	16	7	5	0	0
6-25	33	15	28	19	4	8
1-5	27	12	31	21	16	33
None	108	49	80	54	29	59
Total	221	100	147	100	49	100

(1) *100 grm samples*

Table 5 shows clearly that large numbers of Meadow Nematodes have been collected mostly from estates above 4000 ft. elevation, and only small numbers have been collected below 2000 ft. elevation. Another noteworthy fact concerns the number of estates at all elevations on which the nematodes have not yet been found. As might be expected, the percentage of infested estates appears to increase with increasing elevation. But even at 4000 ft. and above, half the estates are possibly free of Meadow Nematode. Admittedly, this is only a rough estimate, since usually only a very small part of an estate has been sampled, and since our methods do not recover more than perhaps one tenth of the Meadow Nematodes actually present. However, most samples received by the Institute have been taken from areas of declining growth, i.e. those most likely to contain nematodes. This, and the large number of estates included in the survey should tend to make the results more reliable. It is evident, though, that no amount of sampling can provide a guarantee that a given estate is free of Meadow Nematode.

Assuming, therefore, that on an average, one-half of the up-country estates do not yet harbour the Meadow Nematode, it becomes of the greatest importance to prevent its importation into these areas. This re-emphasizes the importance of estates *not* receiving rooted plants from other estates, whether or not these estates are known to be infested. To prevent spread to uninfested areas within a given estate, nursery sites should be sampled to determine if there are Meadow Nematodes present. If nematodes are found to be present, it would be wise to look for another nursery site. However, even if the nursery seems to be uninfested, striking beds should be fumigated before each use, and soil for basketing should also be fumigated. It is possible that the planting of a thick cover of marigold over nursery sites could accomplish the same purpose, and this is being investigated. Infested areas being reconditioned with Guatemala grass should be kept weeded, especially at the edges, to deprive the nematodes of any host plants, and the areas should be situated so that they do not receive run-off water from infested tea. The water used in nurseries might also be a continuous source of nematodes if it comes from infested areas. It would therefore appear that nurseries placed above the tea would be less subject to infestation by nematodes, and that reconditioning of infested tea might better begin at the highest areas. These points, which are more in the nature of advice than a report, are mentioned here because of the increasing evidence of the extreme difficulty, and perhaps impossibility, of eradicating Meadow Nematodes from field soil once they have become established.

TABLE 6.—*Meadow nematodes recovered from estates of* 4000 *ft. elevation and above in Uva, compared with those in Dimbula, Dickoya and Maskeliya*

Number of Meadow Nematodes/100 grm soil	Number of Estates			
	Uva		Dimbula Dickoya Maskeliya	
	No.	estates %	No.	estates %
above 125	1	2	15	11
26-125	3	7	6	19
6-25	5	12	24	1·75
1-5	10	24	14	11
None	23	55	57	41·5
Total	42	100	137	100

The reason for the scarcity of Meadow Nematodes at lower elevations is not positively known, but is possibly due to the higher temperatures in these areas. Table 6, showing their greater prevalence in the Dimbula, Dickoya, and Maskeliya districts, in comparison with Uva, gives this indication. Climate is more severe in Uva, droughts being of longer duration. This could result in heating of the soils to a higher temperature and thus reducing the numbers of nematodes in the upper layers of soil.

The result of the preliminary experiment, wherein tea plants infested with Meadow Nematodes were set out at different elevations, seems to confirm this possibility. At the Kottawa Sub-station of the Institute (elevation 200-300 ft.), where the soil temperature at 12:00 noon taken at 6in. depth ranged from 83 to 92°F. during a four-month period (December 1960 to March 1961), the nematodes died out within 8 months. During this time, and for an additional four-month period, the nematodes maintained their numbers at Hantane Estate (approximate elevation of site, 2600 ft.), and at Oliphant Estate (approximate elevation of site, 7200 ft.), Soil temperatures were not taken at these locations. A confirmatory experiment is in progress, in which records of soil temperatures are being maintained.

A survey of an infested slope at Kirimetiya Estate was undertaken in May, to determine if the infestation at the top (4165 ft.) were less than at the bottom (2685 ft.). No substantial differences were evident in counts made of nematodes in the soil from a total of three points at each of 10 elevations within this range. Soil temperatures were 68° F. at the top of the slope and 80° F. at the bottom. Nematodes were recovered from all 30 locations sampled and moderate numbers were found at 24 locations.

The evidence to hand therefore indicates that the Meadow Nematode can maintain moderate numbers at as low an elevation as 2600 ft. However, as indicated by the general survey, this is an uncommon occurrence. A possible explanation is that such areas have a cooler climate than is usual for that elevation.

(f) Other nematodes associated with tea.—The experiment to determine susceptibility to the root-knot nematode, *Meloidogyne javanica*, of nursery plants of different ages, was concluded. Rooted cuttings of clone TRI 2024 were planted into soil infested with nematodes obtained from roots of *Tephrosia vogellii* grown at Tangakelle and Diyanilakelle estates. The cuttings were all planted at one time, and remained in the soil 2 to 3 months before being examined. A total of 361 root systems, of plants ranging in age from 5 to 12 months, were examined. Of these, 129 roots showed the small swellings typical of injury by this nematode. The results of dissection showed 31 apparently

living second stage larvae in the ungalled roots. In the galled roots, the nematodes apparently living included 116 second stage larvae, 31 expanded larvae, and 3 adult females. No egg masses were found. Approximately equal numbers of dead nematodes were found in the galled roots, and twice the number of dead as apparently living nematodes in the ungalled roots.

Plants of all ages were galled and contained apparently living second stage larvae. Roots of ages 6, 10, and 12 months were found to contain apparently living expanded larvae.

These results are of interest because of the early reports of severe damage caused by this nematode in seedling nurseries, and the apparent resistance to attack of plants approaching 1 year in age. Apparently, clone TRI 2024 is highly resistant to this nematode, since many of the second stage larvae that entered subsequently died, very few matured, no egg masses were found, and galling of roots was very slight. There is no indication that roots of plants 12 months old are any more resistant than are roots of plants 5 or 6 months old. With regard to *M. javanica* as a pest of tea, it should be noted that no reports have been received from Ceylon planters of injury by root-knot nematodes in VP nurseries.

Preliminary host-range experiments with the root-knot nematode of mature tea, *M. brevicauda*, have been concluded. The results show that this nematode failed to colonize roots of any of the 6 plants tested (snap bean, soybean, cucumber, cabbage, tomato, and sweet pepper), when seeds were germinated in infested soil from two localities.

Experiments to determine whether or not the spiral nematodes, *Helicotylenchus nannus*, and *Scutellonema brachyurum*, will multiply on tea were not successful, nor were the experiments with the pin nematode, *Paratylenchus curvitata*. New experiments are being planned.

Publications.—

Hutchinson, M. T. (1961). Developments in the control of the Meadow Nematode. *Tea Quart.* 32: 129-132.

REPORT ON PLANT BREEDING FOR 1961

A. R. Sebastiampillai, B.Sc.

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1. **Staff.**—My work as a post-graduate scholar (Research Officer grade) in plant breeding under the guidance of Prof. Chandraratna of the Faculty of Agriculture (University of Ceylon), Peradeniya, began in May 1961. At the Tea Research Institute the Plant Pathologist effects liaison with Prof. Chandraratna.

2. **Hybridisation.**—The ultimate purpose of the work is the creation of clones that combine quality, yield (including fertilizer response), disease-resistance and pest-resistance, satisfactory growth habit, and other agronomic characters. In tea, self-incompatibility and inbreeding depression obstruct the selection of suitable genotypes within segregating generations. The benefits of re-assortment and recombination that accompany segregation can, however, be secured by the use of a multiplicity of first-generation crosses. All possible crosses between the following clones are being made; TRI 1114, TRI 2024, TRI 777, DT 95 and T 4/10. The number of crosses already made is about 500.

Although this purely empirical approach to hybridisation can be expected to be fruitful, it is desirable that an attempt be made to place the project on a satisfactory genetical basis. A long-range programme has been initiated with the following objectives.

(a) Determination of the heritability and interrelation of yield and quality components in tea.

(b) Calculation of a discriminant function for tea selection.

3. **Floral Biology.**—Familiarity with the anthesis of the flower and the sequence of processes ending in seed maturity is an essential preliminary to the development of hybridisation techniques.

3. 1. **Anther dehiscence.**—The time of anther dehiscence in relation to the opening of the flower was investigated. A free-flowering clone, TRI 1114, was used for this purpose. It was found that anther dehiscence occurs just at the time of opening of the flower or immediately after its opening.

3. 2. **Receptivity of the stigma.**—An experiment was conducted in order to determine the stage at which the stigma is most receptive for successful pollination. Flower buds of clone TRI 2024 were emasculated and pollinated at different daily intervals from the day of opening of the flowers. The results, calculated on a percentage basis, indicated that flowers pollinated on the day of opening gave a better fruit-set than the other treatments.

4. **Controlled pollination between selected parents.—**

4. 1 **Cross pollination.**—Cross pollinations as shown in Table 1 were made during the year 1961.

TABLE 1.—*The percentage fruit set in cross-pollinated flowers of tea*

Female		Male	No. of Crosses	Fruit set	
				No.	Per cent.
(a) TRI 1114	×	TRI 2024	125	30	24
(b) TRI 1114	×	TRI 777	100	2	23
(c) TRI 1114	×	DT 95	100	20	20
(d) TRI 1114	×	T 4/10	54	10	18
(e) TRI 777	×	TRI 1114	96	65	68

4. 2. Self pollination.—Self compatibility was tested in TRI 1114. Only 3% of the selfed flowers set fruit, whereas 20% or more of most crosses were fertile.

cf. 41, 60

REPORT OF THE PLANT PATHOLOGIST FOR 1961

D. Mulder, Nat. Phil. Dr

General.—A third Technical Assistant was appointed: Mr J. P. Herath took up duties in February. The Research Officers continued their advanced work overseas.

1. Fungal Diseases

Blister Blight (*Exobasidium vexans*).—Four aspects of blister-blight control have been under investigation during this year :

1. timing of spraying ;
2. type of fungicide ;
3. method of application ;
4. rate of application.

1. 1. *Timing of Spraying.*—The comparison of records of sunshine with those of surface-wetness, relative humidity, percentage of blister-blight infection, and yield, as announced in the Annual Report for 1960, was carried out during the South-west Monsoon. The result is that although we started spraying on the right date, when the sunshine hours were less than 20 hours over 5 days, the fungicide application did not prevent the development of a severe blister-blight attack, with percentages for third-leaf blisters far above the limit of 35%. This indicates that other measures have to be taken in order to prevent the build-up of the Blister Blight in the first month of the monsoon. A further adaptation of the blister-blight spraying programme is necessary in order to cope with this problem. Not only can we omit spraying rounds during periods of relatively good weather, but we shall also have to insert more spraying rounds during the worst part of the monsoon; this is when weather conditions are such that both the plant and the fungus grow fast. These weather conditions are :

1. fairly high temperature ;
2. high relative humidity ;
3. moderate rainfall ;
4. moderate sunshine.

The question is now how to increase the frequency of spraying at the beginning of the monsoon. Owing to the rapid growth of the bushes, the copper content of the made tea will be low and I am therefore of the opinion that it will be possible to spray every 5 or 4 days (twice in one plucking round) in order to solve this problem of high infection during the early part of the monsoon, which is the striking feature of almost all blister-blight curves since the beginning of spraying trials at the T.R.I.

An alternative method of finding the most critical period for blister-blight control is to work with the automatic spore-trap. Measurements of the concentration of *Exobasidium* spores in the air started in November and since then the pattern of discharge during day and night and over longer periods of weeks and months has been studied. Although the recording of hyaline spores with this instrument is not easy, results are now promising, thanks to the development of the proper staining technique.

1. 2. *Type of Fungicide.*—The number of mixed copper-zinc-carbamate fungicides in the market is rapidly increasing and also several colloidal coppers are available. Therefore more attention was given to the testing of these new possibilities and during the south-west monsoon the following products were used :

Curit "C"
Tubosan
Cuprosan
Duphar colloidal copper
Bharat colloidal copper
Copramat

In order to find differences between those products, low concentrations were deliberately chosen (2 and 4 oz. per acre). Plots of 500 bushes were used and each treatment was replicated three times.

Apart from copper and zinc compounds, an organic sulphur compound (Thiotox) (thiuram 82%) and an organic manganese compound (Mangan curit) (80% maneb) were tried. A completely organic product (Experimental Fungicide 328) was also included in the testing. The results of these trials indicated that Thiotox, Mangan curit and Experimental Fungicide are useless in blister-blight control. Several of the copper-zineb mixtures proved to be quite good. The lower concentration of 2 oz per acre proved to be too little for the colloidal coppers.

Experiments with nickel chloride mixed with zineb and nickel chloride alone showed that the effect of 15 g of nickel chloride alone (roughly $\frac{1}{2}$ oz.) is equal to the average effect of 4 oz. of the copper-zineb combinations, using the same area-dosage of metal. The addition of zineb did not in this case result in improved control.

Furthermore we tried Brestan (triphenyltin acetate) on tea after pruning. This was done too late in the blister-blight season for the result to be considered reliable. Because of some toxicity of this product, only tea recovering from pruning could be sprayed with it.

1. 3. *Method of application.*—The partial switch-over from knapsack spraying to the use of mist-blowers induced us to carry out a series of trials on the method of walking through the field and the handling of the nozzle of the blower.

It was concluded that one-sided blowing is the better way compared with the traditional swinging of the nozzle in front of the man, because a more even spread of the fungicide is obtained.

1.4 *Rate of application by mist-blower.*—It is usually possible to reduce the amount of fungicide used per acre, as well as the amount of carrier liquid, when the method of application is changed from spraying to mist-blowing, which reduces the volume applied per acre to a fifth (in case of Blister Blight) or even a tenth. Because of the fact that the amount of copper fungicide applied per acre for blister-blight control is already extremely small (420 grams per hectare compared with 7000 grams per hectare for Late Blight of potato), it was not necessarily true that this would hold for Blister Blight as well. In co-operation with the Superintendent an experiment was carried out in Fields Nos. 10 and 14B, where areas of approximately two acres were sprayed with 2 oz. per acre, parallel with the normal spraying of 4 oz. of Duphar colloidal copper per acre.

The blister-blight infection was assessed from 9th June to 6th November. In Field No. 10 twenty assessments were done and in Field No. 14B eighteen. The result was as follows :—

Average percentage infection of shoots after mist-blowing.

Field No. / Dosage	Dosage		Number of times infection rose above 20%	
	4 oz	2 oz	4 oz	2 oz
10	21·3	26·1	10	13
14B	24·2	29·2	9	14

The figures indicate that a 50% reduction of the amount of copper results in an average increase in Blister Blight of about 5% at a general level of between 20 and 30%. The increase in Field No. 14B to an average of nearly 30% indicates that it would not be wise to reduce the application to 2 oz. per acre in general, but that the concentration could be varied according to the severity of the Blister Blight in the course of the season from 4 to 2 oz. per acre.

Red Root Disease (Poria hypolateritia).—The research on *Poria* control by D-D fumigation has been carried one step further by the result of the first large fumigation experiment. D-D injected at the rate of 2000 lb. per acre in plots of 20 by 20 feet, which were previously artificially infected, caused complete control of *Poria* in *Tephrosia* sown 6 weeks after the fumigation.

In order to assess the importance of the *Poria* problem, a survey was made of 85 estates covering about 86,000 acres. A total of almost two million rupees had been spent by 42 estates covering 52,000 acres in the course of the last five years alone. This expenditure was not, however, rewarded by efficient eradication. Far too many recurrences along borders of cleared patches have been reported. This suggests that the eradication method recommended by the T. R. I. requires greater attention to prevent the horizontal spread in apparently healthy tea; not enough seemingly-healthty tea had been taken out around *Poria* patches.

Rhizoctonia in the low-country.—A leaf rot causing large irregular necrotic black spots in the younger leaves of clonal plants was identified as being due to an attack by a fungus of the genus *Rhizoctonia* (the species has not yet been determined). Although this disease is of considerable importance when it occurs, its appearance is erratic, depending on the weather conditions. From the weather records during 1960 and 1961, it is clear that the second half of 1961 was very wet in the low-country and this enabled *Rhizoctonia* to attack the young clonal plants both in the nursery and in the field. Apart from that, *Rhizoctonia* was also found to be present in the tops of old seedling bushes in a heavily shaded area. Inoculation experiments have shown the pathogenicity of the fungus.

It is hoped to work out a forecasting system based on sunshine and rainfall data.

Oilspot disease.—On a relatively small number of the highest up-country estates around Kandapola and Nuwara Eliya, oilspot disease is on the increase. No identification of the cause has as yet been possible. DDT sprays failed to control the symptoms. Further work is planned on the hypothesis of a virus being the cause of this disease.

2. Virus Diseases

During work on transmission by grafting of certain diseases that are supposed to be due to a virus, it became clear that a certain amount of incompatibility exists between different types of tea. This is specially apparent between low jat stocks like OK1 and high jat scions like TR1 2024.

Phloem necrotic plants which had not shown any symptom during their stay in the low country started to develop symptoms of phloem necrosis virus disease again after being planted out near Kandapola. This shows that the effect of temperature on this disease is only that of suppression of symptoms.

3. Deficiency Diseases

Magnesium deficiency trials.—A trial on the possibility of spraying a mixture of copper fungicide and magnesium sulphate on clonal plants showing severe symptoms of magnesium deficiency showed that both blister-blight control and reduction of deficiency symptoms were satisfactory after 22 mixed treatments. A trial on the amount of magnesium fertiliser that has to be applied in order to control chlorosis showed that it takes almost two years before any result becomes visible and that Kieserite is the fastest, dolomite the slowest working compound. Giving double the amount of what has been officially recommended resulted in sufficiently rapid control of the chlorosis.

The application of urea on nitrogen-deficient clonal plants by mist-blower.—A trial was conducted on applying urea by knapsack sprayers and mist-blowers. While the knapsack application gave a good result, the mist-blower failed because of the low volume applied and the scorching effect of a very high concentration of urea.

4. Diseases of cover crops and shade trees

Guatemala grass diseases.—The bacterial leaf-stripe disease proved to be of very wide occurrence but did not cause any serious damage.

The stunted growth called "Spikiness disease" was further investigated and found to be also present, although in the form of very mild symptoms, in the low-country (Kottawa Sub-station). Experiments have been carried out in order to identify the nature (probably virus) of this disease.

Acacia decurrens diseases.—Three distinct disease symptoms have been recognised :

1. acute die-back of the top of the tree with growth of healthy shoots lower down from the stem ;
2. yellowing of the tops of all shoots on particular trees which are erratically spread in the hedges ;
3. curling of leaves, dropping of leaflets, stunted growth.

Attempts to grow a fungus from brown discoloured stripes in the wood of trees that had died acutely have failed so far.

5. Decay of shade-tree stumps

A trial has been started on fast rotting of shade-tree stumps by covering them with earth, weeds, or plastic, in Field No. 12. It is hoped that under moist conditions saprophytic wood-rotting fungi will cause a rapid decay so that parasitic fungi cannot use the stumps and roots as starting points for attacks on the surrounding tea. This danger exists specially where the shade trees have been felled without being ring-barked in advance.

6. Identification of leaf-spot on tea

One estate in the Uva district had a serious outbreak of a leaf-spot on clone TRI 2024. Attempts to find and isolate a fungus failed. Diagnosis of the cause was then achieved by carrying out spraying experiments using copper oxide and DDT wettable powder. The spraying of copper did not result in complete control although the spots stayed very small under this treatment.

The DDT spraying resulted in practically complete control of the damage.

It was therefore concluded that the cause was primarily damage done by an insect, after which the spots enlarged by the action of secondary organisms Although no insect was found, it was supposed by comparison of leaf symptoms that the most likely cause has been a *Helopettis* species or at least a sucking insect. The attack developed during a period of high air humidity.

7. Publications

Mulder, D. (1961). A preliminary investigation of the problem of maintenance-leaf fall in the low country. *Tea Quart.* 32: 5-54.

Mulder, D. (1961). How to economise on blister-blight control: the decision to spray based on sunshine records. *Tea Quart.* 32: 88-90.

Mulder, D. (1961). Organic matter and parasitic fungi. *Tea Quart.* 32: 140-142.

Mulder, D. (1961). A bacterial disease of Guatemala grass. *Tea Quart.* 32: 143-144.

Mulder, D. (1961). In: Report on a working party on mist-blowers 14th April, 1961 by J. E. Cranham. *Tea Quart.* 32: 202-203.

Mulder, D. (1961). A revival of tea cider. *Tea Quart.* 32: 222-223.

Mulder, D. (1961). Bacterial leaf-stripe disease of Guatemala Grass (*Tripsacum laxum* Nash). *Commonw. Phytop. News*, 7: 43.

REPORT OF THE PLANT PHYSIOLOGIST FOR 1961

T. Visser, Dr, Ir.

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1. **General.**—Mr K. Amaratunga resigned from his post as Research Assistant in April 1961; Mr D. N. R. Wijewardena and Mr A. D. J. de Croos were appointed as Technical Assistants in June and August respectively, Mr V. S. Kulasegaram as Research Officer in May 1961, and Dr U. Pethiyagoda as Research Officer in December 1961; Mr S. Nagarajah left for the United States in December 1961 for further studies. Altogether 425 letters were received and 580 despatched; about 75 visits were made by the combined staff; most of the correspondence and visits made were concerned with experimental work on sub-stations and estates.

2. **Field Experiments.**—**2.1 Shade Experiment (St. Coombs).**—This replicated experiment on clone TRI 2025 (planted in 1954) consists of three light intensities of 40% and 60% (obtained by screens of Saran) and 100% (no shade) on which are superimposed four fertilizer treatments (N at 100 and 200, K_2O at 50 and 100 lb. per acre; P_2O_5 and MgO constant). It started in May 1961 after having been pre-plucked from December 1960.

The results up to date indicate a depressing effect of shade, the effect being larger at the higher level than at the lower level of fertilizing. Observations are also being made on the proportion of banji and flush and on shoot-growth rates as affected by shade and manurial level.

2. 2. Shade Experiment (Low-country Sub-station).—This trial (on clone TRI 2023) will consist of two shade levels (70 and 100%) and the same fertilizer treatments as at St. Coombs. It was laid out in October, 1961, and will be pre-plucked until March, 1962.

2.3 Pre-pruning.—(*1*) *General.*—Important investigations on pruning methods were carried out in the past by Tubbs (1937) particularly with regard to recovery and the increase of die-back at low elevations. He found that *rim-lung pruning* gave superior results to either *cut-across* or *clean-cut pruning* in the low country. This method involves leaving a few branches with a fair number of leaves on the periphery of the pruned bush; these leaves support new growth by producing the necessary carbohydrates (Tubbs, 1935). *Pre-pruning* has in common with rim-lung pruning that in both methods leaves remain on the bush to support recovery; but the methods differ in the quantity of old leaf left initially and, further, recovery from pre-pruning is supported by young leaves instead of the old leaves in the case of rim-lung pruning. The main feature of pre-pruning is the removal of about 1/5th to 1/6th on each side of the bush or of about 2/5th on one side of the bush about 7-9 weeks before pruning of the remaining part, which is done only after the sides have formed shoots of some length. Thus, recovery of the sides of the bush takes place when the remaining part of the bush is still unpruned, while subsequent recovery of the remaining part occurs in the presence of new shoots already formed on the side.

As this method seemed to have practical possibilities, several experiments have been started at different places since 1957—briefly commented upon

previously (Visser, 1958a, 1959, 1960a, 1961a)—the results of which are described in the following.

In these experiments, pre-pruning done on both sides of the bush will be referred to as side-pruning, when done on one side only it will be called half-pruning. In all but one trial, the remaining part (centre or side) of the bush was plucked until it was pruned (called "'main prune"). This took place only after the pre-pruned side had formed new shoots 3-6 in. long (early pre-prune) or when the side showed bud break only (late pre-prune—in cases where pre-pruning had been deferred for some weeks in comparison to the early pre-prune). The part initially removed from pre-pruned bushes was estimated in all experiments on the basis of a number of randomly chosen bushes; this averaged (by weight) approximately 40% of the total.

(2) *Endane estate (1,000 ft.).*—Small-scale pre-prune experiments were carried out at this estate during the dry season in 1957 and 1958 on a basis of two plots of 100 bushes per treatment.

The first trial in 1957 consisted of six treatments:

(*a*) rim-lung pruning (normal-pruning height 20-24 in.);

(*b*) side-pruning I (normal), followed by the main prune when the sides had formed shoots of 4-6 in.;

(c) side--pruning II (normal), followed by the main prune when the sides showed bud-break (pre-prune 1 month later than (b);

(*d*) as (a) but pruning 6 in. lower;

(*e*) as (b) but pruning 6 in. lower;

(*f*) as (c) but pruning 6 in. lower;

The rim-lung-pruned bushes and the sides of the side-pruned bushes were tipped twice, the centre of the side-pruned bushes only once.

The second experiment at Endane in 1958 consisted of the following treatments:—

(*a*) rim-lung pruning A;

(*b*) side-pruning I, carried out at the same time as (a), pruning the centre after the sides had formed shoots;

(*c*) rim-lung pruning B, about 3 weeks later than (a);

(*d*) side-pruning II, done at the same time as (c), pruning the centre (simultaneously with (b)) when the sides showed bud break.

(*e*) rim-lung pruning C, at the same time as the pruning of the centre in (b) and (d).

Height of pruning and tipping operations were the same as in the first experiment.

TABLE 1.—*Results of rim-lung pruning and side-pruning at Endane carried out in two successive years (yield in lb/acre)*

SEASON 1957

1	2	3		4	5	6	7
Treatments	Date of Pre-prune	Date of		Fresh wt. of tip-pings	Made tea		Dead wood at 16/7/57
		Main prune	First pluck		For 1st 26 plucks	Between 14/2 19/1 1957 & 1958	
Normal height							
(a) Rim lung	——	8/4—18/7 (101 days)		548	911	1178 (35 pl)	126
(b) Side prune I	14/2/57	,,		495	984	1172 ,,	119
(c) Side prune II	15/3/57	,,		486	920	1139 ,,	153
6 in. below normal							
(d) Rim lung	——	15/4—25/7 (101 days)		90	688	945 (34 pl)	486
(e) Side prune I	14/2/57	,,		159	602	979 ,,	1206
(f) Side prune II	15/3/57	,,		150	602	807 ,,	2067

N.B.—*The yield of the centre of the pre-pruned bushes (before the main prune) amounted to nearly 70% of the yield of unpruned bushes (over 8 plucks)*

SEASON 1958

Treatments	Date of Pre-prune	Date of		Fresh wt. of tippings	Made tea		Dead wood at 29/6/58
		Main prune	First pluck		For 1st 7 plucks	Between 15/3 & 19/9 1958	
(a) Rim lung	——	15/3—28/6 (105 days)		1004	233	454 (13 pl)	240
(b) Side prune I	15/3/58	8/5—8/8 (92 days)		1538	313	456 (14 pl)	167
(c) Rim lung B	——	8/4—21/7 (104 days)		965	276	437 (13 pl)	155
(d) Side prune II	8/4/58	8/5—8/8 (92 days)		1044	318	486 (14 pl)	201
(e) Rim lung C	——	8/5—11/8 (92 days)		594	302	514 (14 pl)	84

N.B.—*The yield of the centre of the pre-pruned bushes (before the main prune) amounted to nearly 70% of that of the unpruned bushes (over 7 plucks)*

Although the set-up of these small-scale trials did not allow statistical analysis of the results given in Table 1, certain differences are worth while mentioning.

It can be seen that the differences between treatments in 1957 were insignificant when pruning was done at a normal height (a, b, c). On the other hand, pruning 6 in. lower, restricting the number of leaves present after pruning, notably increased die-back (column 7), particularly that of side-pruned bushes. It is likely that the marked differences between rim-lung pruning (d) and early side-pruning (e) was largely due to the difference in the time of pruning which was done during unfavourable dry weather conditions for (e) and during more

favourable inter-monsoonal conditions for (d). The difference in die-back between early (d) and late (e) side-pruning is probably related to the fact that the main prune of treatment (e) occurred when the sides of the bushes showed bud-break only, so that few new leaves were present to assist recovery of the centre.

The trial carried out in 1958 indicates that side-pruning done in March (b) is better, as judged by tipping weight (column 4) and by the yield over the first seven plucks (column 5), than rim-lung pruning (a) done at the same time. Rim-lung pruning (c) and side-pruning (d) done in April did not differ appreciably; rim-lung pruning (e) in May (at the beginning of the wet season) gave the smallest amount of tippings, but also resulted in less die-back (column 7) than after any of the other treatments.

On the whole, yields over the experimental period (column 6) were little different, irrespective of the pruning treatment, suggesting that pre-pruning had no great advantage over rim-lung pruning.

(3). *Hantane estate* (Hantane Sub-station—2,500 ft).—The trial initiated at this location was similar to that done at Passara (see p. 105) and consisted of seven treatments replicated 5 times (plots of 1/20th acre) and tested in two seasons; the following treatments were compared:

(*a*) rim-lung pruning—3, with 3 branches (lungs) left;
(*b*) rim-lung pruning—6, with 6 branches (lungs) left;
(*c*) cut-across pruning;
(*d*) side-pruning I (early);
(*e*) side pruning II (late);
(*f*) half-pruning I (early);
(*g*) half-pruning II (late).

The pruning of the controls (a, b, c) was done simultaneously with the pre-pruning on treatments (d) and (f); the late pre-pruning (e and g) was carried out 2-3 weeks later. The remaining parts of these pre-pruned bushes were pruned when the sides of the early pre-pruned bushes had formed new shoots; the sides of the later treatments showed less recovery at that time. As at Endane, these second treatments (e and g) were included to see whether differences in recovery would influence subsequent yield and die-back. The pre-prune treatments were brought into plucking by tipping the sides only; the remaining part was brought into plucking by breaking back.

TABLE 2.—*Results of cut-across, rim-lung and pre-pruning at Hantane Estate carried out in two seasons (yield in lb/acre), N. S.=not significant*

SEASON A

1	2	3	4	5	6	7
Treatments	Date of pre-prune	Date of Main prune	Date of First pluck	Fresh wt. of tippings	Made tea For 1st 21 plucks	Made tea Between 23/6 1960 & 19/11 1961	Dead wood per 18/1/61
(a) Rim lung-3	— —	23/6—17/11 (147 days)		391	220	528 (44 pl)	292
(b) Rim lung-6	——	,,		286	191	466 ,,	296
(c) Cut across	——	,,		471	224	530 ,,	348
(d) Side prune I	23/6/60	11/8—6/12 (117 days)		480	215	498 (49 pl)	420
(e) Side prune II	7/8/60	,,		507	231	558 ,,	328
(f) Half prune I	23/6/60	,,		525	238	571 ,,	452
(g) Half prune I	7/8/60	,,		588	226	521 ,,	404
Significant difference at P-0·05				45	N.S.	N.S.	N.S.

SEASON B

Treatments	Date of pre-prune	Date of Main prune	Date of First pluck	Fresh wt. of tippings	Made tea For 1st 21 plucks	Made tea Between 30/11 1960 & 10/11 1961	Dead wood per 7/7/61
(a) Rim lung-3	——	30/1—24/6 (145 days)		511	232	276 (26pl)	552
(b) Rim lung-6	——	,,		496	262	318 ,,	632
(c) Cut across	——	,,		563	244	291 ,,	492
(d) Side prune I	30/11/60	3/2—24/5 (110 days)		415	236	297 (29 pl)	532
(e) Side prune II	14/12/60	,,		442	288	351 ,,	412
(f) Half prune I	30/11/60	,,		340	246	311 ,,	600
(g) Half prune II	14/12/60	,,		284	246	315 ,,	512
Significant difference at P-0·05				54	N.S.	N.S.	N.S.

The results given in Table 2 show that significant differences between tipping weights (column 4) occurred. These differences, however, are not reflected in the yields (columns 4 and 5) or amounts of die-back (column 7) which do not vary significantly between pruning treatments. Apparently, under the conditions of these trials the one method of pruning was as good as the other.

(4) *Downside Estate* (3,000 ft.)—On this estate cut-across and pre-pruning were tested together with several other treatments in a factorial experiment (2^5) which afforded the comparison of 16 plots (each 1/12th acre) for each of the pruning treatments (Visser, 1957).

The sides of the pre-pruned plots were removed on 27th November, 1956, the centres on 17th January, 1957; the cut-across pruning was also carried out on the latter date. Plucking of all plots commenced by the end of May 1957.

TABLE 3.—*Yields in lb/acre after cut-across and side-pruning respectively at Downside Estate*

Treatments	1st year (34 rounds)	2nd year (46 rounds)
Cut across	885 (100·0%)	1173 (100·0%)
Side prune	945 (106·8%)	1199 (102·2%)
Difference at P=0·05	33	43

It follows from the data given in Table 3 that the pre-pruned plots yielded more tea in the first year than the plots which were cut-across; the difference, though not marked, was significant. The yields recorded over the second year after pruning did not differ significantly . Die-back was not recorded in this trial.

(5) *Gonakelle Estate* (Passara Sub-station—3,400 ft.).—The first experiment at this location was carried out at the beginning of the rush season in 1958, and had the following treatments which were 7 times replicated each (plot size 1/24th acre);

(*a*) cut-across pruning (A) at the time that the sides were pruned on the side-pruned plots;

(*b*) cut-across pruning (B) at the time that the centres were pruned on the side-pruned plots;

(*c*) side-pruning followed by pruning of the centre when sides had formed shoots of 4-7 in; centres plucked until the main prune ;

(*d*) side-pruning as above, but the centre left unplucked (rested for 8 plucks).

Pruning in all treatments was done at a height of about 13-16 in. above ground level. The bushes which were cut across and the sides of the pre-pruned bushes were tipped; the centre of the latter was not tipped but brought into plucking along with the sides by breaking back.

TABLE 4.—*Results of cut-across and side-pruning at Gonakelle Estate* (*yield in lb/acre*)

1	2	3	4	5	6	7	8
Treatments	Date of Pre-prune	Date of Main prune	Date of First pluck	Fresh wt. of tippings	Made tea For 1st 12 plucks	Made tea Betweem 15/3 & 18/11 1958	Dead wood at 20/8	Dead wood at 28/11
(a) Cut-across A	——	15/3—22/7 (129 days)		1960	350	558 (18 pl)	141	305
(b) Cut-across B	——	12/5—26/8 (106 days)		751	363	604 (21 pl)	114	328
(c) Side-prune & resting	15/3/58	12/5—22/7 (71 days)		851	295	491 (18 pl)	91	202
(d) Side-prune & plucking	15/3/58	12/5—22/7 (71 days)		958	286	624 (18 pl)	91	235
Significant difference at P=0·05				213	45	68	36	40

N. B.—*The yield of the centre of the side-pruned bushes* (*before main prune*) *amounted to 70% of the yield of unpruned bushes* (*over 8 plucks*)

It can be seen from the results presented in Table 4 that the cut-across plots yielded significantly more over the first 12 plucks (column 5) than the pre-pruned treatments (compare a and b with c and d). However, the yields per pluck showed that the differences between treatments decreased with time. It is worthy of note that cut-across pruning in March (c) produced more than twice as much tippings (column 4) as similar pruning 2 months later (b) when the drought set in, but the enhanced shoot growth did not show in terms of increased yield subsequently (column 5).

Resting the centre for 8 rounds appeared to have had no advantage, as the subsequent tipping weights and yields (columns 4, 5) did not significantly differ from those of pre-pruned bushes of which the centre was plucked prior to its pruning (compare c and d). The loss of crop incurred through resting explains the significantly lower yield of this treatment over the total period of the experiment (column 6) as compared with that of the other treatments, which did not differ significantly. It may be noted that the pre-pruned plots could be brought into plucking considerably earlier than the cut-across plots (column 3).

The data given in columns 7 and 8 showed that pre-pruning caused significantly less die-back than cut-across pruning. Comparing the amounts of die-back recorded at the two dates, it is evident that an appreciable amount of die-back must have occurred after the bushes came into bearing.

A second trial similar to that done at Hantane (see p. 103) was carried out in a different field consisting of 7 pruning treatments tested in three different seasons; each treatment was replicated 5 times (plot size 1/20th acre) in each season (seasons in sub-blocks). The treatments were the following:—

(*a*) rim-lung pruning—3, with 3 branches (lungs) left;
(*b*) rim-lung pruning—6, with 6 branches (lungs) left;
(*c*) cut-across pruning;
(*d*) side-pruning I (early);

(*e*) side-pruning II (late);
(*f*) half-pruning I (early);
(*g*) half-pruning II (late.)

The main prune on the pre-pruned treatments was done at the same time as that of the controls (a, b, c); it was carried out on the early pre-prune treatments (I) when the sides had formed shoots of 3-7 in; the recovery of the late pre-prune treatments (II) was less advanced; all treatments were pruned at the same height. The pre-prune treatments were brought into plucking by tipping the pre-pruned portion only.

TABLE 5.—*Results of cut-across, rim-lung and pre-pruning at Gonakelle Estate carried out at different times of the year (yield in lb/acre)*

SEASON A

1	2	3	4	5	6	7
Treatments	Date of pre-prune	Date of: Main prune / First pluck	Fresh wt. of tippings	Made tea: For 1st 27 plucks	Made tea: Between 8/10 1959 & 21/11 1961	Dead wood at 22/4/60
(a) Rim lung-3	——	3/12/59—14/4/60 (133 days)	1600	413	1503 (77 pl)	338
(b) Rim lung-6	——	,,	1231	437	1624 ,,	348
(c) Cut across	——	,,	1726	410	1476 ,,	380
(d) Side prune I	8/10/59	3/12/59—31/3/60 (119 days)	1290	366	1449 (79 pl)	342
(e) Side prune II	22/10/59	,,	1269	401	1629 ,,	392
(f) Half prune I	8/10/59	,,	1230	398	1580 ,,	405
(g) Half prune II	22/10/59	,,	1131	421	1746 ,,	422
Significant difference at P=0·05			368	N.S.	N.S.	N.S.

N. B.—*The yield of the remaining part of the pre-pruned bushes (before the main prune) amounted to 75% of the yield of unpruned bushes (over 9 plucks)*

SEASON B

Treatments	Date of pre-prune	Date of: Main prune / First pluck	Fresh wt. of tippings	Made tea: For 1st 27 plucks	Made tea: Between 10/2 1960 & 21/11 1961	Dead wood at 13/1/60
(a) Rim lung-3	——	14/4—5/10 (174 days)	1723	735	1265 (55 pl)	796
(b) Rim lung-6	——	,,	1597	711	1276 ,,	680
(c) Cut across	——	,,	1948	709	1248 ,,	1132
(d) Side prune I	10/2/60	14/4—13/8 (121 days)	1378	543	1293 (61 pl)	604
(e) Side prune II	27/2/60	14/4—24/9 (163 days)	2695	692	1242 (56 pl)	700
(f) Half prune I	10/2/60	14/4—13/8 (121 days)	1624	585	1426 (61 pl)	532
(g) Half prune II	27/2/60	14/4—24/9 (163 days)	2627	686	1292 (56 pl)	576
Significant difference at P=0·05			511	144	N. S.	389

N. B.—*The yield of the remaining part of the pre-pruned bushes (before the main prune) amounted of 85% of the yield of unpruned bushes (over 10 plucks)*

SEASON C

Treatments	Date of pre-prune	Date of Main prune	Date of First pluck	Fresh wt. of tippings	Made tea For 1st 27 plucks	Made tea Between 14/7 1960 & 21/11 1961	Dead wood at 28/1/61
(a) Rim lung-3	——	24/9/60—21/3/61 (178 days)		1678	829	904 (37 pl)	604
(b) Rim lung-6	——	,,		1618	784	856 ,,	516
(c) Cut across	——	,,		2023	853	930 ,,	620
(d) Side prune I	14/7/60	24/9/60—25/1/61 (123 days)		1295	765	1007 (43 pl)	608
(e) Side prune II	28/7/60	,,		1720	792	1055 ,,	424
(f) Half prune I	14/7/60	,,		1754	741	987 ,,	544
(g) Half prune II	28/7/60	,,		1663	722	936 ,,	592
Significant difference at P=0·05				327	N.S.	113	N.S.

N. B.—*The yield of the remaining part of the pre-pruned bushes (before main prune) was about equal (98%) to the yield of unpruned bushes (over 10 plucks)*

It can be seen from the results presented in Table 4 that recovery after pre-pruning as judged by the weight of tippings (column 4) did not greatly differ from that of the controls (a, b, c), except in Season B where the late pruning (e and g) gave nearly twice as much tippings as the early pre-pruning (d and f). This is probably due to the fact that the former treatments were brought into plucking 6 weeks later. The tipping weights recorded after the cut-across prune were generally higher than after rim-lung pruning, presumably because the lungs of the latter treatment (removed 6-8 weeks after pruning) did not contribute much to tipping weight.

As regards the yields after the first 27 plucks (column 5), differences between treatments are not very marked in most instances. The differences between the controls and late pre-pruning on the one hand and early pre-pruning on the other in Season B again indicate the influence of difference in time allowed for recovery. The yields obtained over the entire period of the trial (column 6) do not significantly differ between treatments in Seasons A and B; the yields of the side-prune treatments (d and e) were better in Season C when pruning was done during dry weather.

The amount of die-back (column 7) recorded 5-6 months after pruning was not greatly affected by the pruning treatments; it was only significantly increased by cut-across pruning in Season B where recovery took place during dry weather.

Summing up this series of trials, it does not appear that the pre-pruning methods were outstandingly better than the standard ones, though possibly of some advantage when pruning is done during the dry season; recovery after pruning was quicker (column 3) in all instances. Averaging all three trials and putting total yield after cut-across pruning at 100%, those of the rim-lung treatments were 101% and 103% (for 3 and 6 lungs), those following side-pruning 103% and 107% (for I and II) and those for both half-pruning treatments were 109%. Similarly, the figures for die-back (cut-across 100%) are 81% and 72% for rim-lung, 73% and 66% for side-pruning and 70% and 75% for half-pruning . Thus it would appear that both rim-lung and pre-pruning were slightly better than cut-across pruning in these trials.

The trial clearly indicates the effect of the time of pruning in relation to climatic conditions on the yield obtainable after the bushes were brought into

plucking. The average yields for the first 27 plucks were 496, 666 and 784 lb. per acre for Seasons A, B and C respectively.

(5) *St. Coombs* (4,500 *ft.*).—This experiment was done to test the effect of different heights of pre-pruning; the treatments were replicated 5 times (plot size 1/20th acre) and were the following :—

(*a*) clean-cut pruning (low) at a height of 9-12 in.;

(*b*) clean-cut pruning (high) at a height of 12-15 in.;

(*c*) side-pruning (early) sides and centre pruned low;

(*d*) side-pruning (early) sides and centre pruned high;

(*e*) side-pruning (early) sides pruned low, centre high;

(*f*) (g) and (h) side-pruning II (late), treatments same as (c), (d) and (e) respectively, but side-pruning was done 4 weeks later and the centre pruned at the same time as the side-pruning I treatments.

The centre of the side-pruned bushes was pruned at the same time as the controls (a and b).

TABLE 6.—*Results of clean-cut and side-pruning at St. Coombs Estate* (*yield in lb/acre*)

1	2	3		4	5	6
Treatments	Date of pre-prune	Date of Main prune	Date of First pluck	Fresh wt. of tippings	Made tea For first 22 plucks	Made tea Between 2/4 1957 & 10/5 1958
(a) Clean cut pruned low	——	13/6—2/11 (192 days)		1573	625	691 (30 pl)
(b) Clean cut pruned high	——	3/6—16/10 (135 days)		970	572	690 (30 pl)
Side prune I	2/4/57					
(c) Sides low centre low	——	13/6—30/9 (109 days)		727	599	877 (34 pl)
(d) Sides high centre high	——	3/6—10/9 (99 days)		600	595	842 ,,
(e) Sides low centre high	——	3/6—10/9 (99 days)		421	598	851 ,,
Side prune II	29/4/57					
(f) Sides low centre low	——	13/6—30/9 (109 days)		469	620	871 (34 pl)
(g) Sides high centre high	——	3/6—10/9 (99 days)		370	599	853 ,,
(h) Sides low centre high	——	3/6—10/9 (99 days)		253	549	795 ,,
Significant difference at P=0·05				223	N.S.	133

N. B.—*The yield of the centre of the pre-pruned bushes* (*before the main prune*) *varied between 110 and 130% of that of the unpruned bushes* (*over 7 plucks*)

It can be deduced from Table 6 (column 3) that the side-pruned bushes could be brought into plucking much earlier (by tipping of the sides only and breaking back the centres), than the clean-pruned bushes which were tipped

in the normal way. The latter also explains the significantly higher tipping weights obtained from the clean-pruned bushes (column 4).

It also appeared that low pruning enhanced shoot growth (in terms of tippings) more than high pruning, both for clean-cut and side-pruned bushes. Low pruning of the sides combined with high pruning of the centre (e and h) was observed to depress the growth of the sides as compared with either high or low pruning of both sides and centre and led to lower tipping weights (column 4).

Notwithstanding the differences in tipping weight, the yields for the first 22 plucks were approximately the same, irrespective of the pruning treatment (column 5).

With respect to the yield over the entire period (column 6), the data show that the side-pruning treatments yielded significantly more than the clean-cut plots. This is due both to the fact that the side-pruned bushes were brought into plucking sooner and also to the fact that the centre of these bushes yielded over the period between the side-prune and the main prune more than unpruned bushes over the same period.

As die-back was negligible, it was not recorded.

(6) *Conclusions.*—The trials show that, as regards crop, pre-pruning is in most instances not appreciably better than the standard methods applied in the given district. Indications are that it may decrease die-back to some extent when pruning is carried out during or at the onset of a dry weather period.

This is probably related to the fact that pre-pruned bushes are less vulnerable than normally pruned bushes, because recovery occurs in two stages. New growth on the pre-pruned side is supported by the remaining unpruned part which, following pruning, is in turn assisted by the presence of new foliage on the pre-pruned part.

Observations suggest that the main prune should be carried out only after the pre-pruned part has formed new shoots; pruning at a time when the pre-pruned portion shows only bud-break may be harmful. Pruning of the side lower than the remaining part was observed to impede to some extent new growth on the pre-pruned portion. Tipping of the pre-pruned part only and bringing the subsequently pruned portion into plucking by breaking back appeared to be a satisfactory procedure.

As a consequence of pre-pruning the bushes are out of plucking for a shorter period (by 2-7 weeks) than normally pruned bushes, as after pre-pruning the remaining part is plucked for 7-10 weeks before it is due for pruning. This may be of an advantage, *e.g.* in Uva, where for reasons of management dry-weather pruning is done. Thus pre-pruned bushes, notwithstanding the removal of 40-50% of the plucking surface, would continue to produce, when prices are good, at least 70% of the normal crop. The trials indicate that the loss of crop over the pre-prune period may be less than 30% or even nil.

Half-pruning (on one side of the bush) is more practical than side-pruning (on both sides of the bush) with respect to mossing, ferning and blister blight control. However, both methods are impractical when shot-hole-borer control is carried out as a post-pruning treatment.

2. 4 Guatemala grass experiment.—This short-term field trial was conducted by Mr Rajendram to assess how and to what extent the cutting height would affect subsequent growth. The grass was established in January 1960

(planted at 2×2½ ft.). In November 1960 plots of 20×20 ft. containing 40-48 plants (including guard rows) were laid out and the plants were cut at 18 in., 24 in. and 30 in. above ground level respectively (each treatment twice replicated). One month later the numbers of the cut shoots (each plant had 20 to 30 shoots) that showed terminal growth were determined and how many had formed axillary shoots; both terminal and axillary shoot-growth were expressed as percentages of the total numbers of shoots present. In March 1961 all plots were cut at treatment height and the weights of the loppings determined.

TABLE 7.—*The effect of cutting-height on the growth of Guatemala grass*

Height of cut Nov. '60	December 1960		Dry wt. of loppings per acre March 1961
	% terminal growth	% axillary growth	
18 inches	45	52	7·05 tons (100%)
24 „	61	39	9·05 tons (129%)
30 „	89	14	9·30 tons (132%)

Table 7 shows that cutting the grass relatively high accelerates terminal growth of the shoots; but diminishes the stooling out of the plants, as shown by the smaller percentage of side-shoots when compared with that of plants cut nearer to ground level. It is worthy of note that the difference in lopping weight between plants cut at 18 in. and cut at 24 in. is marked, while that between plants cut at 24 and 30 in. is insignificant. Observations indicated that cutting at 24 in. or 30 in. occurred above the growing region of the shoots, while at 18 in. the growing regions were often damaged with a resultant loss in growth.

Accordingly, it would seem that the grass should not be cut too low (not below the growing region) if the aim is to obtain the greatest possible amount of loppings. In fact indications are that the grass should also be cut as infrequently as is practicable, since frequent lopping would probably reduce the amount of organic material obtainable in a given time (both above and below ground level).

2. 5. Mulch determinations under tea and shade trees.—These were done in Field No. 9 at St. Coombs (pruned in July 1959). In this field 5 plots were chosen of about 22 ft. square which had *Grevillea robusta* trees, 20-30 years old, at the four corners. In December 1960 these plots were swept clean of all leaf litter and twigs from both tea (prunings) and trees, which averaged 4.23 tons of dry matter per acre. This process was repeated in January 1962 when the mulch obtained was also roughly separated into litter from tea and that from trees; the total amounted to 1.38 tons per acre of which 53% (0.73 tons) originated from tea.

As the first assessment represented an accumulated total over several years including the litter from pruning 18 months previously, it is not surprising that it was so much higher than that found an year later, which represented only the litter accumulated over one year. The amount of 0.73 tons from tea is higher than that estimated previously (Visser, 1960c) and the total is higher than that determined by Eden (1937) in Passara (0.8 tons/acre for both tea and trees). It cannot compare, however, with the approximate 6.5 tons dry matter (29% from tea) annually found in Kenya for tea under a very heavy stand of old *Grevillea* trees (Child, 1960).

3. Growth observations on young tea plants.—

3. 1 Reconditioning experiment.—This trial was carried out to investigate the influence of different cover crops planted after the uprooting of the old tea on the subsequent growth of the newly replanted tea. For this purpose an area of old tea was divided into 20 plots of about 10 ft. square (exclusive of 3ft. guard belt between plots). In December 1959, the tea on 16 of these plots was uprooted and 4 (chosen at random) were left in tea. The plots of which the tea was uprooted were treated as follows (4 plots/treatment): kept fallow (occasionally weeded); planted with Guatemala grass; planted with marigolds; and planted with grass plus marigolds respectively.

The cover crops as well as the tea remaining on 4 plots were uprooted about ten months later; half the plots were fumigated in November 1960 (all plots temporarily thatched) so that each of the 5 treatments was represented by 2 fumigated and 2 unfumigated plots (treatments randomised). Each plot was planted in December 1960 with 20 lots each of 3 plants arranged triangularly at 12 in. between plants within lots and about 16 in. between plants of different lots. This arrangement was made for the purpose of regular growth assessments on lots of 3 plants per treatment at a time. Plants of clone TRI 2025 (propagated March 1960, put in polythene bags August 1960) were used; they were manured at 1 oz. of the usual mixture containing organic nitrogen every two months; the trial was unshaded.

Plant growth—root weight, leaf weight and area, shoot weight—was assessed 20 times (first assessment 9th March, last 30th November 1961) at fortnightly intervals. It appeared that the log-values of the plant weights, when plotted against time, constituted a linear regression in which the regression coefficient represents the growth rate over the period in question. The regressions for all 10 treatments were found to be very highly significant (correlations between log weight and time of the order of 0.99) and they thus served as a reliable measure to indicate differences in growth rates between different treatments.

TABLE 8.—*Regressions for the growth of young tea plants (y=dry weight/planting) in relation to time (x=weeks) following different soil-reconditioning treatments*

Tea planted after :	Fumigated	Not fumigated
Tea	log y=0·425+0·0374 x	log y=0·465+0·0341 x
Fallow	log y=0·463+0·0398 x	log y=0·538+0·0341 x
Grass	log y=0·450+0·0386 x	log y=0·450+0·0390 x
Marigolds	log y=0·459+0·0402 x	log y=0·425+0·0387 x
Grass+marigolds	log y=0·424+0·0393 x	log y=0·567+0·0343 x
Regressions for fumigated and unfumigated	log y=0·436+0·0398 x	log y=0·506+0·0361 x

N. B.—*Significant difference (at P=0.05) for the regression coefficients of x for fumigated and unfumigated treatments is 0.0024; that for individual regression coefficients is 0.0047.*

It can be seen from Table 8 that the growth rates of the tea plants, as judged by the regression coefficients, did not differ significantly if the soil was fumigated prior to planting. The growth rates of the plants in fumigated soil were on an average higher than those of plants in unfumigated soil. Without fumigation, the plants after grass grew significantly faster than those after tea, fallow or the mixed cover crop. The growth rate of plants after marigolds was similar to that after grass but just not significantly different from that of the other treatments.

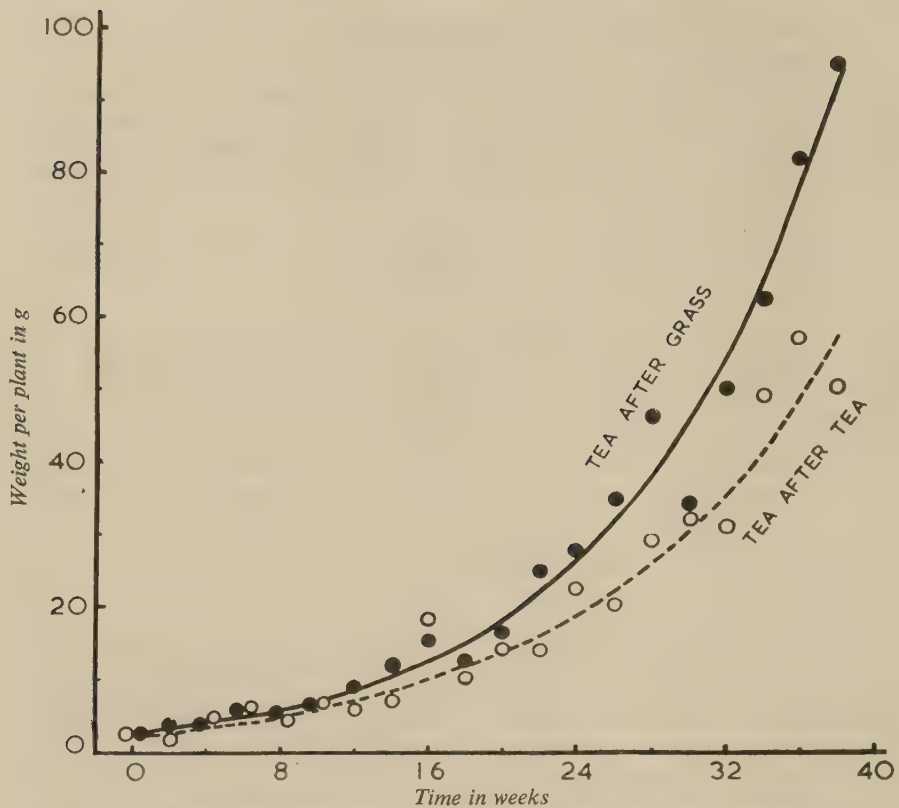

Fig. 1—The growth of tea plants planted directly after the uprooting of mature tea and after an intervening period of grass cultivation respectively (plants 1 year old at start).

Fig. 1 serves to illustrate the observed growth trends; it represents growth (plant weight on an arithmetic scale) in relation to time from the first assessment after tea and after Guatemala grass respectively (soil unfumigated). It will be seen that the growth curves are about the same at the beginning but deviate more and more with time.

No obvious conclusions can be drawn from this trial as regards soil reconditioning. The fact that tea after tea does not grow significantly more slowly than tea after fallow or after the mixed cover crop hardly implies the occurrence of soil-sickness, nor is it clear why, in unfumigated soil, tea after grass or after marigolds grows better than that after other treatments. This cannot be attributed to a depressing effect of these crops on a meadow-eelworm population, for soil sampling showed the absence of this pest in all treatments.

3. 2 The effect of removal of shoots and roots at transplanting (St. Coombs, Passara, Hantane).—The aim of these trials was to investigate the influence of the partial removal of the shoots, sometimes done to reduce transpiration and to encourage branching, and of root damage, such as may occur while transplanting, on the subsequent growth of the plants.

The experiments, carried out at 3 locations, consisted of 4 replicated treatments: (1) control; (2) part of the roots removed; (3) part of the shoots removed; (4) part of both roots and shoots removed. At Kottawa (300 ft.) about half, at Passara (3500 ft.) and St. Coombs (4500 ft.) about one third of roots and/or shoots were removed. The plants at Passara (clone TRI 2025) were in baskets, those at St. Coombs (clone TRI 2025) and at Kottawa (clone TRI 2024) were in polythene bags (removed when transplanted). They were 12, 9 and 6 months old respectively at the start of the trial.

TABLE 9.—*Weight of plants (in grams) 4-6 months after removal of part of the roots, shoots, or both, at the time of transplanting at different locations, with the weight shown as percentages of the controls (in brackets)*

Location	Control	Roots removed	Shoots removed	Roots & shoots removed	Sign. diff. at P=0·05
Kottawa	15·48 (100)	9·72 (63)	9·04 (58)	6·50 (42)	2·84
Passara	9·54 (100)	9·13 (96)	6·92 (73)	6·77 (71)	1·79
St. Coombs	3·85 (100)	2·96 (77)	2·56 (67)	1·88 (49)	0·21

Table 9, which summarises the main results, shows that the removal of shoots at Passara reduced growth significantly, but the partial removal of roots had no effect, presumably because the transfer of plants growing in partly deteriorated baskets caused in itself a similar loss of roots in the control plants. At Kottawa and St. Coombs, where the plants grew in polythene bags, either root or shoot removal led to a significant loss in growth; removal of both roots and shoots reduced growth still further.

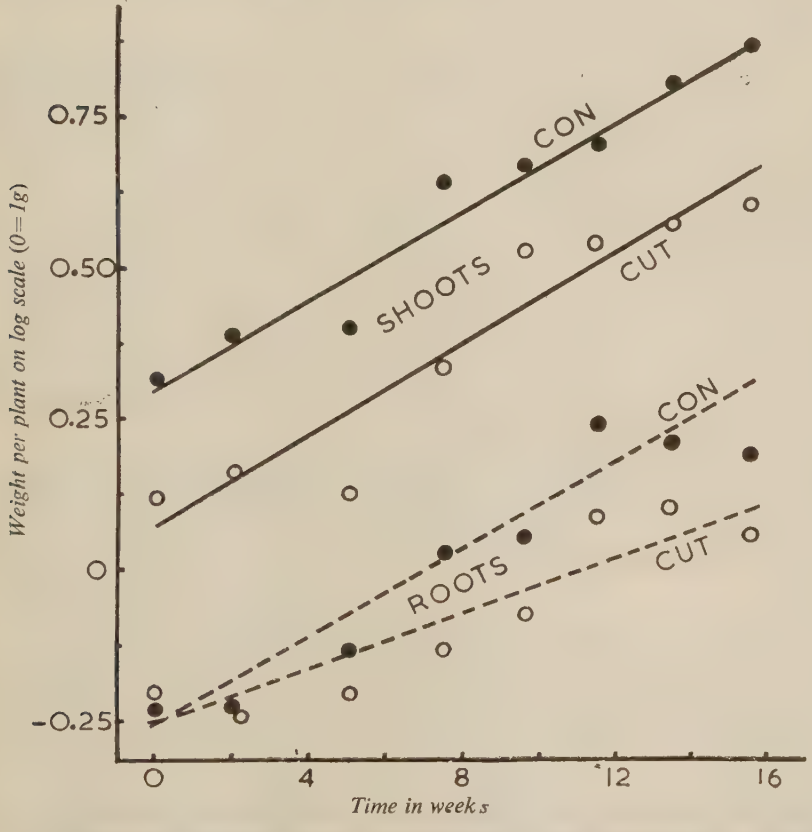

Fig. 2—The effect of the partial removal of the shoots (cut) on the subsequent shoot and root growth in comparison with that of undamaged plants (con)—plants 9 months old at start. Regressions for root and shoot growth (Y=dry wt. in g) with time (X=weeks): the regressions are highly significant.

Treatments	Shoots	Roots
Control	log y=0·376x+0·305	log y=0·0330x—0·250
Shoots cut	log y=0·0369x+0·079	log y=0·0230x—0·257

When transplanting it is of importance, therefore, to avoid any bringing-into-bearing treatments which entail leaf and shoot removal, until the plant is well established.

In a second trial on clone TRI 2025 at St. Coombs the effects of partial removal of the shoots on the subsequent growth rate (g/week, log scales) of roots and shoots were investigated. The amount of shoot removed was 28% of total plant weight; undamaged plants served as a control. The two treatments were divided at random over 48 plots each containing 28 plants (exclusive of guard-row plants) planted at 6½ in. triangular. This arrangement allowed 8 fortnightly assessments on 3 plots per treatment on each occasion ; the plants were 9 months old at the start of the trial.

It can be seen from Fig. 2 that the partial removal of the shoots significantly decreased the subsequent growth rate (slope of the line) of the roots, but did not affect that of the shoots. The size of the uncut control plants at the end of the period was naturally more—actually 70% more. Other trials suggest that when the roots are partly removed the rate of shoot growth may be reduced. This matter is still under investigation.

3. 3 Growth measurements of young tea plants.—The 20 fortnightly assessments, done during the reconditioning trial (see 3.1) on tea plants, also allowed the calculation of the relative growth rate, net assimilation rate, and leaf-area ratio. The leaf area of the plants were determined by the punching method; this was done by (a) weighing the leaves and (b) punching a known area out of a representative part of each leaf by means of a cork borer and weighing the discs. In effect, the discs give the weight per unit area, so enabling the total area to be calculated. The validity of this method was tested by comparing it with actual area determinations by means of blue-print paper. The respective measurements for growth were determined on the basis of 10 random lots of 6 plants at each occasion. They were calculated as the averages over 4-week intervals in order to avoid negative values in those few instances where the subsequent assessment gave lower weights or areas than at the prior assessment, *e.g.* due to temporary dormancy of the plants combined with variation between the lots of plants assessed on different occasions.

TABLE 10.—*The relative growth rate (RGR), net assimilation rate (NAR) and leaf-area ratio (LAR) of unshaded tea plants, 12 months old at the start of the assessments*

Period (1961)	RGR g/g/day	NAR g/dm²/week	LAR dm²/g
9/3—6/4	0·0120	0·184	0·455
6/4—4/5	0·0128	0·175	0·519
4/5—1/6	0·0165	0·189	0·525
1/6—29/6	0·0131	0·143	0·602
29/6—28/7	0·0088	0·143	0·563
28/7—24/8	0·0127	0·118	0·606
24/8—21/9	0·0173	0·238	0·593
21/9—19/10	0·0080	0·164	0·539
19/10—16/11	0·0097	0·119	0·539
16/11—30/11	0·0101	0·131	0·541
Average	0·0121	0·160	0·548
Standard error	±0·0010	±0·012	±0·014

It can be seen from Table 10 that the relative growth rate and net assimilation rate varied more than the leaf-area ratio. It seems likely that these fluctuations are related to changes in environmental conditions (rainfall and sunshine), but this could not be demonstrated statistically. Possibly, shorter assessment intervals or a longer period of observation would be required for such a purpose.

The trial carried out at St. Coombs for the purpose of ascertaining the effect of partial removal of shoots on growth (see 3.2) also allowed the calculation of the relative growth rate. This averaged over the 16-week period of the trial 0.0111 and 0.0092 g/g/day for the control and the damaged plants respectively (difference just not significant for $P=0.05$). Thus the loss of shoots amounting to 28% of total plant weight decreased the relative growth rate by only 17%.

The magnitude of the various values for growth is of the same order as those found previously in our shade trials at different locations (Visser, 1961 b).

4. Carbohydrate analysis.—

The analysis of the starch reserves in many hundreds of root samples from different locations and differently treated tea bushes was nearly completed by Mr Nagarajah before he left for studies abroad; his work is being continued by Mr Rajendram.

TABLE 11.—*Carbohydrate reserves, expressed in % starch, of roots of tea bushes after pruning at 3 locations*

Location	At pruning July '60	Plucking Dec. '60	7 months plucking July '61
Hantane (2500 ft)	8	1	5
Passara (3500 ft)	11	3	5
St. Coombs (4500 ft)	19	8	11

Table 11 gives some preliminary figures on the starch reserves of roots of bushes after pruning. These indicate that the starch reserves in the roots increase with elevation (confirming results of Tubbs, 1935), and that pruning lowers these reserves more with decreasing elevation. It is further confirmed that it takes more than a year before the reserves are restored to the same level as before pruning (Visser, 1960b).

5. Study of estate yields in relation to fertilizing.—

A survey of yields and fertilizer trends over the period 1947-1957 was carried out in 1958 on the basis of data from 12 well-managed estates comprising nearly 10,000 acres (Visser, 1958b). It appeared that the yields had increased approximately linearly with both time and fertilizer application.

These data were again analysed by Hasselo (see Report of the Agronomist for 1961) whose studies indicated that manuring on a ratio basis is a doubtful agricultural principle.

The scope of the initial investigation was subsequently widened and for this purpose some 120 estates were requested to send yield, fertilizer, and rainfall data, over the period 1949-1960. The response was very favourable, as complete sets of figures of 90 estates were obtained by the end of 1961. These represent 15 districts (5-7 estates per district): Galle, Kalutara, Rakwana, Ratnapura (Dehiowita), Matale, Knuckles, Pussellawa, Dimbulla, Agrapatna, Dickoya, Nuwara Eliya, Uda Pussellawa, Welimada, Badulla (Passara) and Bandarawela (Haputale).

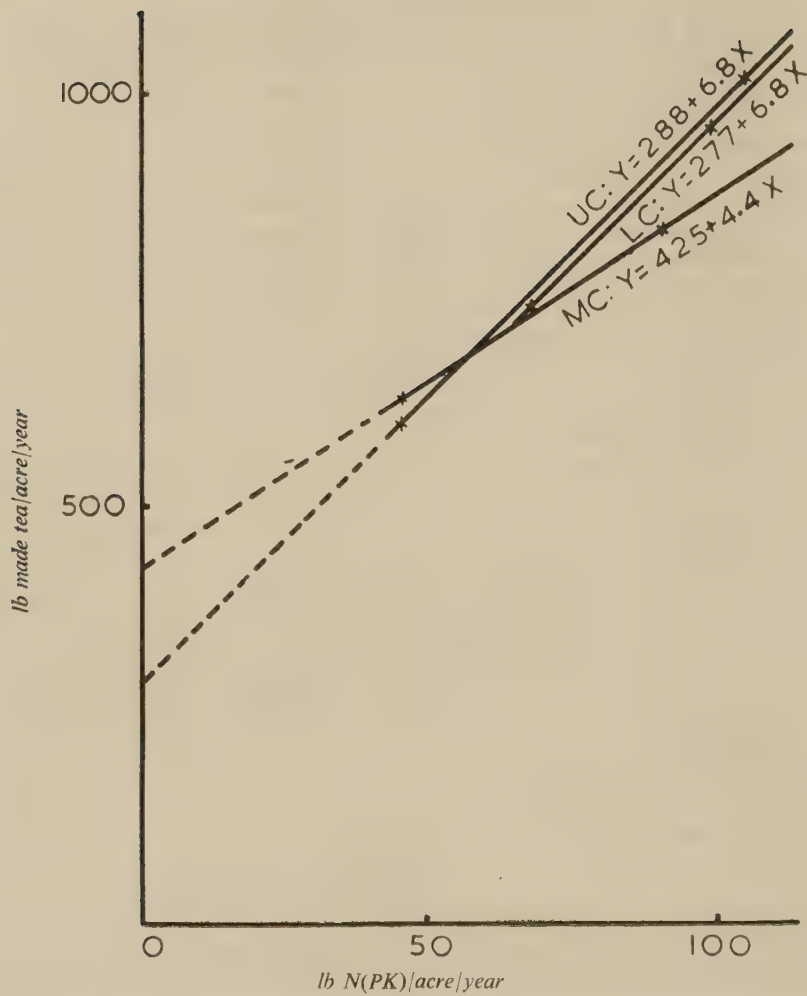

Fig. 3—The relation between N (PK) applications and yield for low (LC), mid (MC) and up country (UC) estates.

Fig. 3 gives the regressions for yield against N(PK) for tea below 2,000 ft. (LC—23 estates), between 2,000 and 4,000 ft. (MC—26 estates) and above 4,000 ft. (UC—37 estates). The up-country and mid-country regressions have been extrapolated for purposes of illustration.

It can be seen that the (extrapolated) yields at zero N are 288 and 425 lb respectively (values of the constants in the formulae); at 100 lb of N the yields are 967 and 869 respectively. Thus, the expenditure of 100 lb N(PK) was accompanied by the production of 679 lb (967—288) and 444 lb (869—425) of tea respectively. Accordingly, the fertilizer expenditure index, or FI for short, defined as the amount of tea associated with the expenditure of every one pound N(PK) is 6.8 for the up-country and 4.4 for the mid-country estates. The values of 6.8 and 4.4 representing the regression coefficients (of x) in the formulae differ statistically, possibly denoting a reduction in yield due to Shot-hole Borer.

These figures for the FI are much less than those which seem obtainable on the basis of the ratio-principle which implies that *e.g.* at a 8 or 10-lb ratio,

12.5 or 10 lb tea per 1 lb N(PK) can be obtained, which is obviously not correct. It must be stressed, however, that also the lower values for the FI of 4.4 or 6.8 do not express the actual fertilizer efficiency, which is likely to be lower. Due to the linkage between yield and fertilizer applications on account of the ratio-principle, regressions such as shown in Fig. 3 are apt to obscure cause and effect; they also include a management factor (Hasselo, 1962).

Therefore, while appraising the relation between past yields and fertilizer doses on an estate it should be kept in mind that the ensuing graph estimates fertilizer expenditure but not fertilizer efficiency.

6. Incidence of calcium oxalate crystals in the tea leaf petiole.—

The sampling required for this study started in 1960 and was conducted by Mr K. L. D. Amaratunga; it was discontinued in 1961. A preliminary report has been given previously (Visser, 1961a); the results are summarised more extensively in the following:

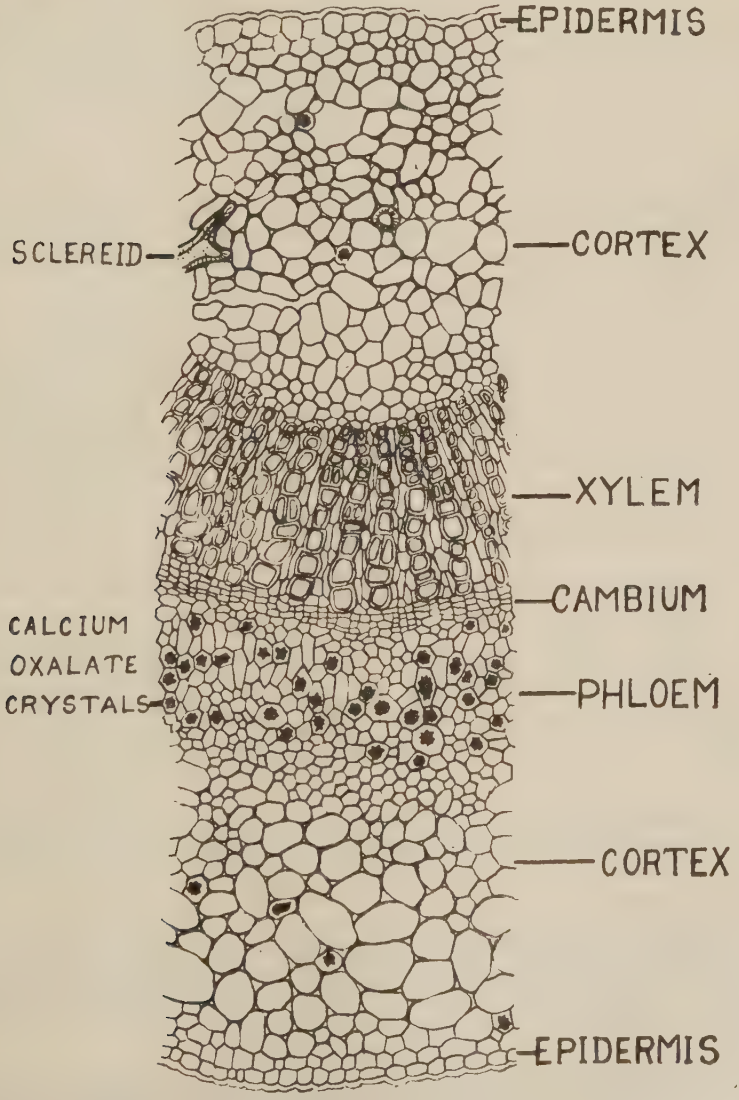

Fig. 4—Cross section of a petiole of a tea leaf.

6.1 General.—The presence of calcium oxalate crystals in tea was noted by Greenish (1923), who considered it a characteristic of genuine tea, *Camellia sinensis* (L). De Haan (1939), in a systematic study of the anatomy of the tea shoot and leaf, observed calcium oxalate crystals in the cortex of crop shoots and in the parenchyma tissue of the leaf. The occurrence of such crystals in the phloem parenchyma of the tea leaf petiole (as illustrated by the cross section of a petiole of a tea leaf in Fig. 4) has been extensively studied by Wight and his co-workers in Assam.

They defined the total number of crystals present in the phloem of a transverse section of the petiole as the ''phloem index'' or P. I. (Wight & Green, 1954). This index, determined from expanded leaves of comparable age, was observed to remain notably constant for a particular phenotype or clone and seemed not to be influenced by minor variations in agricultural conditions. Investigations of Wight and Green (1954), Wight and Barua (1954), and Wight (1958a) indicated that the P. I. can serve as a genetically determined parameter in defining tea agrotypes. Significant relations were also found between the P. I. and inherent bush characteristics (of populations) such as yield, yield intensity, and bush area, as well as with the mineral content of the leaves (Wight and Barua, 1954; Barua, 1956; Wight, 1958a, 1958b and 1959). The P. I. further appeared to be positively related to light intensity (Barua and Dutta, 1959).

Wight and his co-workers used mainly populations for their studies. Our aim was to study inherent and environmental variability of clones in order to find out whether the P. I. could be used as one of the means of defining clones.

6.2 Variability of the Phloem Index.—Preliminary observations indicated that the phloem index of one given bush or clone could vary markedly, so that a study was made of possible causes of variation. The method used, unless mentioned otherwise, was the following: The petiole, together with about 1 cm length of midrib, was cut from the leaf and preserved in 70% alcohol, if not sectioned immediately. Thin sections were cut with a razor blade from a standard position (about the middle of the petiole). Sectioning started at the lowest point of attachment of the petiole with the stem; 15—20 thin sections were cut and discarded. The best out of the next 3 sections were examined. The material was mounted in 70% glycerine.

(1) *Crystal number and sample size.*—The standard error of the mean of a given number of examinations varied with the magnitude of the P. I. according to their crystal number. Arranging in categories 95 means (each of 10-20 samples) of several clones, it appeared that the standard error decreases from 25% of the mean for less than 10 crystals in the petiole to 8% of the mean for 40-50 crystals, drops further to 3-5% for means between 50 and 100, and rises again to 7% for crystal frequencies above 100. This increase is presumably partly due to the difficulty in counting accurately large numbers of crystals.

With regard to sample size, the standard error was on an average 5.3% of the mean of 10 and 4.1% of the mean of 20 examinations when the P. I. was between 60 and 70; for crystal numbers above 100 the standard errors were 6.8 and 5.5% respectively.

(2) *Distribution of crystals in the leaf petiole.*—Counting the crystal numbers (means of 11 determinations) in sections made from the basal, middle, and apical regions of the leaf petioles of two clones showed that the P. I. markedly increased from the base to the apex of the petiole: the P. I. of one clone more than doubled, the P. I. of the other increased by 37%

(3) *Variability with leaf maturity.*—Leaves of shoots of recently pruned bushes and of bushes in plucking were examined. In the former case primary

shoots with 10-15 leaves were selected, the upper seven of which were examined, in the latter case flush shoots were chosen with three leaves and a bud, including the leaf in the axil of which the shoot originated (termed axillary leaf). The means were determined from two leaves of each of 10 bushes of two clones.

The P. I. of leaves of primary shoots appeared to increase with the position of the leaf from the apex downwards, reaching a maximum in the 4th leaf, and to decrease somewhat in the 3 lower leaves. The crystal numbers for the seven successive leaves from the apex downwards averaged: 12, 44, 56, 64, 58, 56 and 52. The somewhat smaller crystal numbers of the lower leaves are probably connected with the growth periodicity of the shoot. When growth slows down the leaves become slightly smaller and appear to contain fewer crystals than leaves formed when the shoot resumes its activity. Sampling leaves from the mature red-wood portion of the shoots showed that the larger leaves contained 12% more crystals than the smaller ones.

The P. I. of leaves of flush shoots was found to increase markedly with leaf maturity, averaging 41 for the axillary leaf, 29, 20 and 7 crystals for the petioles of the first, second, and third (last) leaves formed on the shoot. Apparently only the axillary leaf, which is 2-3 months older than the first leaf of the crop shoot, can be considered fully mature.

(4) *Variability within the bush and between bushes.*—A comparison was made between leaves from the periphery and the centre of the bush. Two leaves of each category of ten bushes of two clones were examined, using both shoots from pruned bushes and from bushes in plucking. The petioles of the leaves from the centre were found to contain significantly more crystals than those from the periphery of the bush for both clones; the mean difference was 14% in the case of primary shoots and 22% for flush shoots.

As regards the variability between bushes, crystal counts were made of petiole sections of 11 leaves from one bush and from one leaf of each of 11 bushes respectively; two sets of counts were made in two clones. These showed that the mean P.I. for one bush differed significantly (by 22% on an average) from the mean P. I. determined on the basis of 11 bushes.

(5) *Variability between clones.*—A general idea of the variation in the phloem index was obtained from the examination of 79 different clones which were selected for testing in the nursery and which came from different locations in Ceylon; 12 leaves of primary shoots (4-6th position from the apex downwards) were examined per clone.

The clones were arranged in categories according to their crystal frequency —not more than 20, 21-40, 41—60, etc. The number of clones in each category is graphically presented in Fig. 5.

Fig. 5 shows that the P. I. may vary between wide limits, *viz.* from less than 10 crystals to more than 150; two clones had a P.I. of as much as 235, (omitted in the Figure). About half the clones had a P.I. between 30 and 70. The skewness of the graph—more clones with a P. I. above 40 than below—possibly indicates a weak relation between the crystal number and yield, because the clones were selected for high yield.

Evidence on the question of whether or not the P.I. has a genetical basis was sought by comparing the crystal frequencies of 10 clones growing at 3 different locations: Neuchatel (50 ft.) Passara (3,500 ft.), and St. Coombs (4500 ft). The bushes were all in plucking; two axillary leaves of each of 7 bushes were examined.

The crystal frequencies of the clones ranged from about 10 to 120 and, though varying between locations, were relatively constant for the clone. This

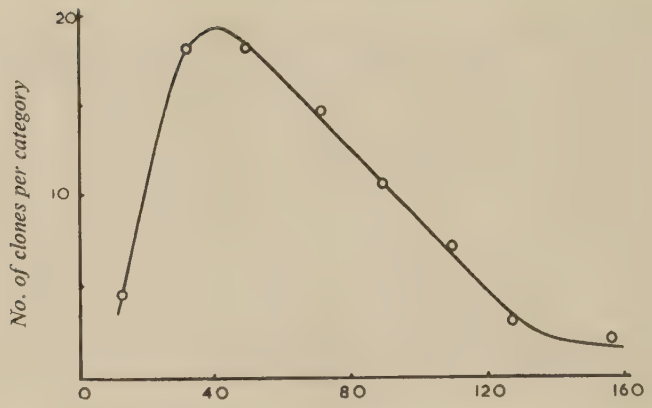

FIG. 5. The classification of 77 clones according to their phloem index category

was borne out by the highly significant correlations existing between the crystal numbers of clones from different locations and which amounted to:

+0.928 for St. Coombs with Passara
+0.948 for St. Coombs with Neuchatel
+0.981 for Passara with Neuchatel.

(6) *Variability with environment.*—The effect of light intensity on the P.I. (also described earlier: Visser, 1961b) was investigated in an experiment in which 15-month-old plants of clones TRI 2024 and 2025 were grown under screens transmitting 42%, 62% and 69% of daylight, with unshaded plants as a control. This experiment was carried out at 4 locations of different altitudes: Neuchatel (50 ft), Passara (3500 ft.), St. Coombs (4500 ft.), and Pedro (6000 ft.). At each location 20 leaves per treatment were examined; on that basis accurate averages were obtained, judging by the low individual standard error for each treatment, which amounted in no case to more than 5% of the mean. The results for locations and light intensities are summarised in Table 12.

TABLE 12.—*The effect of various light intensities and sites (altitudes) on the phloem index*

Site	Light intensity				Means for site	
	42%	62%	69%	100%	2024	2025
Neuchatel	64	76	89	104	84	83
Passara	72	79	87	106	75	72
St. Coombs	70	80	91	106	91	83
Pedro	59	67	77	86	84	61
Means for light 2024	74	82	99	109	Sign. diff. for means is 5·0 at P=0·05	
Means for light 2025	59	69	79	92		

The data presented in Table 12 show a significant tendency of the P. I. to rise with increasing light intensity at all locations; the increase is approximately linear with the logarithm of the light intensity (Visser, 1961b). There seems

to be no specific relation in these data between the P.I. and the altitude of the site.

The possible effect of altitude (temperature) on the phloem index was more extensively investigated by examining the leaf petioles of clones TRI 2024 and 2025 from 20 different elevations ranging between sea level and 6700 ft.; 12 leaves per clone per elevation were examined.

The correlation of the P.I. with the elevation was non-significant for clone TRI 2025 (+0.381) and only just significant for clone TRI 2024 (+0.466). Thus, there is hardly a reliable relationship; in so far as the correlation points to a positive relation it is probably not associated with altitude but with light intensity. The plots from which the leaves were collected tended to be more heavily shaded at the lower elevations than at the higher ones.

6.3 Conclusions.—The observations on the phloem index made it apparent that many factors can cause marked variations in the P.I. of any given clone as it varies: (a) from the base to the apex of the petiole; (b) with leaf maturity; (c) with leaf size; (d) with the position of the leaves in the bush (centre or periphery); (e) with shade; and (f) according to Wight and co-workers, with nutrient uptake, bush area, etc.

Although some of the observations imply a link-up between crystal number and physiological activity in terms of growth, its value as a general indicator is doubtful unless the environmental factors are known and rigidly controlled as for example in our shade trial. It was found that the average P.I. obtained on a single occasion, though in itself reliable as judged by the small standard error, may differ as much as 100% from that of the same clone growing somewhere else or under different conditions. If the average P. I. of a clone was determined as a mean of several occasions—namely from bushes of different areas—the difference between two such means may still be of the order of 25%.

It is concluded, therefore, that the phloem index—though an inherent clonal characteristic—cannot serve as a reliable means for clonal identification because of its variability with environment. It may, in some cases, provide contributory evidence regarding the identity of a clone.

7. Potato trials.—

7.1 Testing for wilt resistance.—Tests for the resistance against wilt (*Pseudomonas solanacearum*) started in January 1960, in my own garden with the screening of about 350 potato varieties and selections out of which only 40 were found to be worth re-testing. This number has since been reduced to only 7 varieties, after several more tests both at St. Coombs and in locations. Of these, IVP 654 has shown superior resistance in the six tests carried out so far; Gelderse Rode and Zeeburger also appeared fairly resistant but are low yielders; Hilla, though not as resistant as the former three, gives very good yields; Ambassadeur showed little susceptibility in 3 tests and will be re-tested at more locations; Noordeling and Eigenheimer showed a fair resistance initially, particularly the former, but have not come up to expectations in the last tests.

Trials are to be continued with these varieties as well as with a number of South American selections and some crossings made (in the Netherlands) of IVP 654.

7. 2 Yield Trials.—It was realised that potatoes may have possibilities on estates as a cash crop, to be grown after uprooting the old tea and before reconditioning. Therefore, in March 1961, trials were initiated at St. Coombs (4500 ft.), Passara (3300 ft.), Welimada (3000 ft.) and Hantane (2500 ft.), partly

to investigate the possibility of potato cultivation in tea land and partly to test the yield capacity of 9 potato varieties. The outcome of these small-scale trials (70 tubers per variety per location) was promising; no wilt occurred at St. Coombs and Passara, and only a little wilting was seen at Welimada and Hantane, though between 10% and 35% of the tubers were found to be rotted, possibly due to potato blight and soil organisms other than wilt. The yields when expressed on an acreage basis, varied between 5 and 9 tons, depending on the variety and location. On an average the varieties Eigenheimer and Voran were found to yield significantly more than any of the others.

In October 1961 three more replicated trials were initiated: (a) in one garden with six varieties; (b) in 8 gardens at St. Coombs with 5 varieties; and (c) in tea land (1/6th acre) soon after uprooting the old tea, with 9 varieties. The garden trials produced yields equivalent on an average to 5—6 tons per acre, but certain varieties yielded significantly more. The field trial in tea land gave crops between 5 and 8 tons per acre, depending on the variety, while wilt was negligible.

Furthermore, during 1961 the "Estate Potato Scheme" was initiated in co-operation with Dr Abeygunawardene of the Regional Research Station at Gurutalawa. The aim of this scheme was to investigate potato cultivation under estate conditions; a small number of estates undertook to grow $\frac{1}{4}$—$\frac{1}{2}$ acre plots of potatoes. The full results are not yet known; two estates at about 3,000 ft. have reported failure due to wilt; two plots at higher elevations appear to be in a healthy condition.

Summarising the results obtained so far, it would appear that potato cultivation in tea land at altitudes above 4,000 ft. has economic possibilities, for crops of between 5 and 7 tons can be obtained with the application of fertilizers and efficient disease control.

I am greatly indebted to Dr H. J. Toxopeus of the Institute of Agriculture Plant-breeding and Ir J. A. Hogen Esch of the Institute for Research on Field-crop Varieties at Wageningen for their interest and assistance in providing the material for these experiments. My sincere thanks are also due to the superintendents of estates co-operating in these trials.

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REPORT OF THE STATISTICIAN FOR 1961

P. Kanapathipillai, B.Sc.

Staff.—I assumed duties as Statistician on 14 October, 1961, having been seconded by Government to the services of the Institute.

Analyses.—During this period the Division was mainly concerned with analyses of data collected previously.

Multiple regression analysis of the annual yield of tea on the independent variates N, P, K was done on one of the high-elevation estates. It was found that none of the variates significantly influenced yield. It must be mentioned, however, that the variates, N, P, K are not really independent of yield. Some estates adjust their fertiliser applications to the yield, and hence the validity of the analysis will, to that extent, be vitiated. Dr S. C. Pearce of East Malling Research Station, added a fourth independent variate, namely, number of days of frost. Even then, no significant association with yield could be established. Subsequently, however, he re-examined the data and the results will appear in a forthcoming report.

A similar analysis was performed on four independent variates N, P, K and annual rainfall on one estate in South India. The inference was drawn that nitrogen together with the factor "years", significantly influenced yields. A more detailed statistical study of methods of examining the relationship of nitrogen applications to yield is being made by Dr Pearce on data collected by Dr Visser from a number of estates in Ceylon.

Comparison of theaflavin content of clones of different quality.—Fifty clones were classified into four groups by the Technologist according to their quality. The Biochemist collected data on the theaflavin and chlorophyll contents on a series of samples in these four groups. Covariance analysis of the data, allowing for a significant association ($r=+0.608$) of theaflavin content and chlorophyll content, showed that the mean theaflavin contents were:

Clone — Groups			
A_1	A_2	B	C
.577	.573	.502	.479

These extinction coefficients were found to be highly significantly different ($P<0.01$).

The division gave statistical advice on problems of design, sampling and analyses of data to the other Research Divisions.

REPORT OF THE TECHNOLOGIST FOR 1961

E. L. Keegel

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1. **Staff.**—Messrs A. H. R. Balthazaar and W. C. A. de Silva joined the Division as Technical Assistants on 1st April.

2. **Advisory.**—66 visits were made to factories, and 736 samples examined, arising mostly from these visits.

3. **General.**—A visit was made to Tocklai about the middle of the year by the Technologist, as a member of a delegation, to examine the continuous rollers developed by the Engineering Development Branch of the Tocklai Experimental Station.

Two machines, the Rotorvane (R. V.) and the Tocklai Continuous Roller (T. C. R.) were studied with a view to their possible application in Ceylon. They are fundamentally different in design and action. The R. V. is tubular, with a hopper at one end and a discharge at the other. A rotary and linear motion is imparted to the leaf, and the necessary rupturing of the cells is brought about by revolving vanes and fixed resistors on the inner surface of the cylinder. In the T. C. R. the rolling action is effected by means of two rubbing surfaces, between which the leaf is continuously passed. Leaf is fed at one end and discharged at the other. Pressure is applied by means of spindles on the upper plate.

From an examination of the teas produced by these machines it was concluded that the T. C. R., however suitable it may be for Assam conditions and requirements, does not impart the twist required in Ceylon. For our low-country manufacture with separation of tip, a conventional initial roll will probably do as well. If continuous-flow manufacture is pressed for, the value of the machine would have to be reconsidered.

The Rotorvane on the other hand appears to meet a certain need. On account of the treatment the leaf receives, it is probable that the R. V. would improve the liquoring properties, with some loss of appearance, and therefore it might be particularly applicable to the mid-country. It is unlikely that the R. V. could be used for the initial stages of rolling unless the demand for twist in Ceylon teas diminishes; for twist the orthodox roller will still have to be used for at least the early rolls. The R. V. may therefore be useful for breaking the twisted leaf without the use of additional rollers. A machine is to be tried out at St. Coombs in the near future.

4. **Clonal manufacture.**—

4.1 Testing of individual bushes.—Of the 500 bushes selected in 1960 with a view to discovering bushes of superb manufacturing characteristics, only one seems to have come up to the required standard, and this is now being reserved for cross-breeding with clones of known properties. It could be classified as a low-jat bush.

There does not appear to be a correlation between size of leaf and quality according to the observations made on the leaf characteristics of the rejected bushes. Observations are being continued on a further 400 bushes.

4.2 Testing of clones.—As in previous years assistance was given to estates and to the Plant Physiology Division in quality tests. A large number of clones were examined, some repeated on a scale larger than the mincing machine technique, the results of which will appear in a separate article in the Tea Quarterly.

In the light of the information now available, some of the clones listed in the Tea Quarterly, Vol. 30 (Keegel 1959) may require re-classification. For example, clone TRI 425 which was classified as A2 may have to be considered for promotion to A1, whilst DT 95 has not come up to our expectations when compared with DT1, which continues to receive excellent reports.

4.3 Reliability of small-scale tests.—Doubts about the reliability of small-scale tests for assessing the potential characteristics of clones have been expressed from time to time. The techniques now adopted at the Institute have been the outcome of numerous tests carried out in the past, the results of which were unfortunately not published and are now almost impossible to trace. With a view, therefore, to putting the issue beyond all doubt, a few experiments were carried out with ordinary estate leaf to check the accuracy of our techniques. Table 1 shows the combined average marks (out of 10) given by 8 tasters on 5 separate experiments.

TABLE 1.—*Relationship between four different methods of manufacture*

	INFUSION	COLOUR	STRENGTH	QUALITY	VALUATION
1. Commercial manufacture	5	5	5	5	Rs. 2.41
2. Experimental (30 lb. W.L.)	5	6	5	5	„ 2.40
3. Miniature (1 lb. W.L.)	5	6	6	4	„ 2.37
4. Mincing machine (1½ ozs. W.L.)	7	6	6	4	„ 2.34

It will be seen that the results of the different treatments are practically identical except in the case of the infused leaf from the mincing machine technique—something to be expected. The harsh characteristics which small-scale tests tend to impart to teas also detract from quality.

However, making due allowance for the way in which certain properties of a tea are favoured or disfavoured in small-scale tests, the results on the whole indicate that our techniques are reliable enough for assessing a clone. It seems reasonable to assume that a given clone when manufactured on a commercial scale would not give very different results from those that would be expected according to its assessment from a small-scale technique.

5. Age from pruning.—(Tea at 6000 ft. elevation—Nuwara Eliya district).—Comparison of two lots of leaf with a difference of 44 months in the ages of pruning was continued (Keegel, 1961). In January, 1961, the respective ages of the plots were about 2 years and 5½ years.

No specific effects were found from extending the pruning cycle other than those that were to be expected from 'older' leaf. The slight difference in quality between corresponding samples was hardly enough to increase the value of the tea from the 'older' leaf. This long-term experiment will be brought to a close in 1962, when the data collected will have to be statistically analysed before any definite conclusions are drawn.

We should like to take this opportunity of acknowledging our thanks to Mr N. M. Sanders of Pedro Estate for his co-operation in these trials.

6. Withering materials.—Extensive investigations were conducted on Tygan mesh and Nylon net, with particular reference to the characteristics of the tea made from leaf withered on these materials.

6.1 Rate of withering on open-mesh materials.—The extent to which the withering period could be shortened by the use of such materials depends on many factors. However, an attempt was made to obtain a rough indication of the difference in the rate of withering between open mesh and hessian on a very small scale. The results so far are inconclusive.

Observations on a larger scale show that for the same rate of spreading (of 1 lb. to about 8 square feet) the period of wither for Nylon net (4 meshes to the linear inch) is shortened by about 3 hours. The minimum amount of heated air was used in order to wither the leaf in the maximum period likely to be experienced under normal conditions in a factory. Periods of wither were approximately 22 hours for leaf spread on hessian and 19 hours on Nylon.

It would appear from the average results of 20 experiments that this small difference in the period of wither tended to improve quality. This advantage in favour of Nylon was, however, obtained at the expense of colour.

6.2 Effect of thicker spreading of leaf on the made tea.—

(i) Hessian versus Nylon (16 experiments). No difference.

(ii) Hessian versus Tygan (19 experiments). No difference.

In the case of (i) 50% more leaf was spread on Nylon and in (ii) 20% more on Tygan. Rate of spreading for hessian was 1 lb. per 10 square feet.

6.3 Other experiments on rate of spreading.—As far back as 1951 (Keegel 1952) results of experiments on Tygan mesh (14 perforations to the inch) revealed that there was no appreciable improvement in the rate of wither by the use of this material. On the other hand, claims have been made by an estate using Tygan that by spreading 25% more leaf on Tygan it was possible to get a wither equivalent to that on hessian. Further trials indicated that 20% more leaf could be accommodated on Tygan without adversely affecting the wither.

As a result of more observations on the effect of different rates of spreading on hessian there do not appear to be sufficient grounds for changing the views we previously held on Tygan. In 12 experiments comparing a normal spread on hessian with a thicker spread and with the same spread on Tygan we noted no difference in the rate of wither or in the characteristics of the made teas. The rates of spreading were as follows:

Hessian	—	1 lb.	per	10	sq.	ft.	(control)
,,	—	1 ,,	,,	8½	,,	,,	(20% more leaf)
Tygan	—	1 ,,	,,	8½	,,	,,	(do)

An explanation for these curious results is that there was an adequate volume of air available. So it may be concluded that any difference in the rate of wither between Tygan and hessian, in favour of the former, would be more noticeable if the air flow is not sufficient for the amount of leaf spread. The spacing between tats is another factor. Under favourable conditions hessian would give the same results as Tygan (14 perforations to the inch).

The general conclusions we could draw from the results of these experiments are:

1. For a substantial improvement in the rate of wither the material must have reasonably large mesh. Anything larger than 4 meshes to the inch would restrict removal of leaf from tats.

2. The volume of air should be increased proportionately with the extra amount of leaf accommodated on any type of tat material.

3. Thicker spreading of leaf has no detrimental effect on the made tea provided the right conditions are given.

6.4 Types of plastic material.—In last year's Annual Report (Keegel 1961) the relative merits of open-mesh material and the factors concerning their use for withering tats were discussed. Apart from the consideration that synthetic plastic materials because of their toughness and tensile strength could be expected to last longer than hessian, one great advantage a tat of plastic material has over hessian is that it does not sag. More even withers would therefore result from the substitution of a plastic material for hessian. One and perhaps the only factor initially against its adoption was its cost, but now that Nylon net can be imported free of duty, its price is no more than twice that of hessian.

With the present serious anxiety over the lack of withering accommodation on account of increasing crops, plastic netting would no doubt have a wide application. It should be stressed, however, that if the material is to be used for accommodating more leaf, fan capacity should be increased. One limiting factor in increasing the size or speed of fans is the velocity of air flow through *one single loft*. If air speeds are so high as to blow leaf off the tats nearest the bulking chamber when only one loft is employed, a simple expedient is to divert a part of the air into another loft and thereby supply the required volume of air for the amount of leaf spread in that particular loft. The more economical method of tackling such a situation is, of course, by means of variable-speed fans. The delivery of air from the fans could then be varied according to crop and to the number of lofts used at any time.

There are many types of plastic net now available in the market which could be considered suitable for withering tats. The synthetic fibres from which they are woven bear such names as Nylon, Tetoron, Evilon, Saran and so on. Their tensile strengths probably differ but we are not in a position to comment on their relative merits at this stage. However, their durability would depend on the thickness and number of strands composing the twines and also on the weave. Price varies accordingly and the choice depends on individual preference.

The type of net first introduced for withering tats was of the knotted variety and it was felt that the knots would wear off more quickly than the rest of the material due to abrasion in the process of collecting the leaf. For this reason knotless Nylon netting might hold more promise; it is now available in different grades.

One of the problems associated with Nylon netting (the diamond-mesh type) is that it has to be fully stretched at the time of installing it. The tension is so great that tat posts have to be reinforced. Mono-filament plastic yarn however does not seem to possess this property, judging from samples of some material produced in the U. K. and U. S. A. If, as it is claimed, this material maintains its original dimensions, and the size and shape of the apertures does not alter, its inherent stability might give it an advantage over Nylon net, It is difficult to tell whether it has a greater degree of resistance to friction than Nylon. Anyway, there is a wide range of open-mesh material to meet the general demands of the industry. There is also the pre-shrunk square-mesh knotted type of Nylon which need not be stretched to the same extent as the diamond mesh; tat posts would therefore be subject to less tension.

Fibre-glass is another material that has been considered but, however tough it may be, its use is prohibited because glass fibres become easily detached once abrasion takes place. Broken glass fibres, however small in amount, constitute a danger to health.

7. Storage of leaf to delay wither.—In anticipation of the proposed experiments to be conducted on the withering drum and trough witherer, for which leaf may have to be stored for considerable periods prior to withering, some storage experiments were conducted to study the changes, if any, which take place in the leaf.

The results of 25 experiments (including some carried out in 1960) are as follows :

(i) *Stored in rolling room for* 24 *hours*

(a) Normal wither of approximately 20 hours

(b) Slow wither of approximately 44 hours

(c) Stored for approximately 24 hours and withered for 20 hours.

Delaying the wither on these lines is just as harmful for quality as extending the period of wither. Whether the leaf is withered or not, in the early stages of the process colour is developed at the expense of quality.

The average valuations for these teas were as follows:

Normal	—	Rs. 2.51
Slow	—	Rs. 2.41
Delayed	—	Rs. 2.36

These experiments were confined to leaf only 10-15 months from pruning, and there can be no doubt that bigger differences would have been obtained with leaf in which quality was more pronounced.

(ii) *Stored for shorter periods and given shorter withers* (approximately 14 and 8 hours respectively).

There was hardly any difference in the teas between the delayed wither in this instance and a normal wither of about 16 hours.

It would appear from these results that if leaf is to be stored for any length of time, the actual withering period should be as short as possible to off set any chemical changes adverse to quality occurring during the period of storage.

8. Rolling.—In the Annual Report for 1960 (Keegel 1961) reference was made to a new type of batten, which was primarily developed to match the Keegel cone. Tests on a commercial scale have given very promising results in the early rolls. These battens, from the evidence so far available, do not appear to be particularly suited for a last roll where a high dhool production is required. This matter is being investigated.

However, as far as the early rolls are concerned the use of these battens in conjunction with a Keegel cone tends to improve the appearance of a tea without loss of liquoring properties when compared with the battens in general use. Those estates wishing to experiment with this extremely simple roller table are strongly advised to follow the dimensions given in Table 2 as closely as possible. Small variations in the lengths of the battens are permissible because of differences in the diameters of doors and tables. The battens must, however, in every instance terminate at the door as shown in Figure 1. It is also important to see that pressure caps are free of battens or other devices.

It need hardly be emphasized that, to get the best results from this new roller table, charges should not exceed those given in Table XIII on page 52 of Monograph No. 4—2nd Edition—Tea Manufacture in Ceylon.

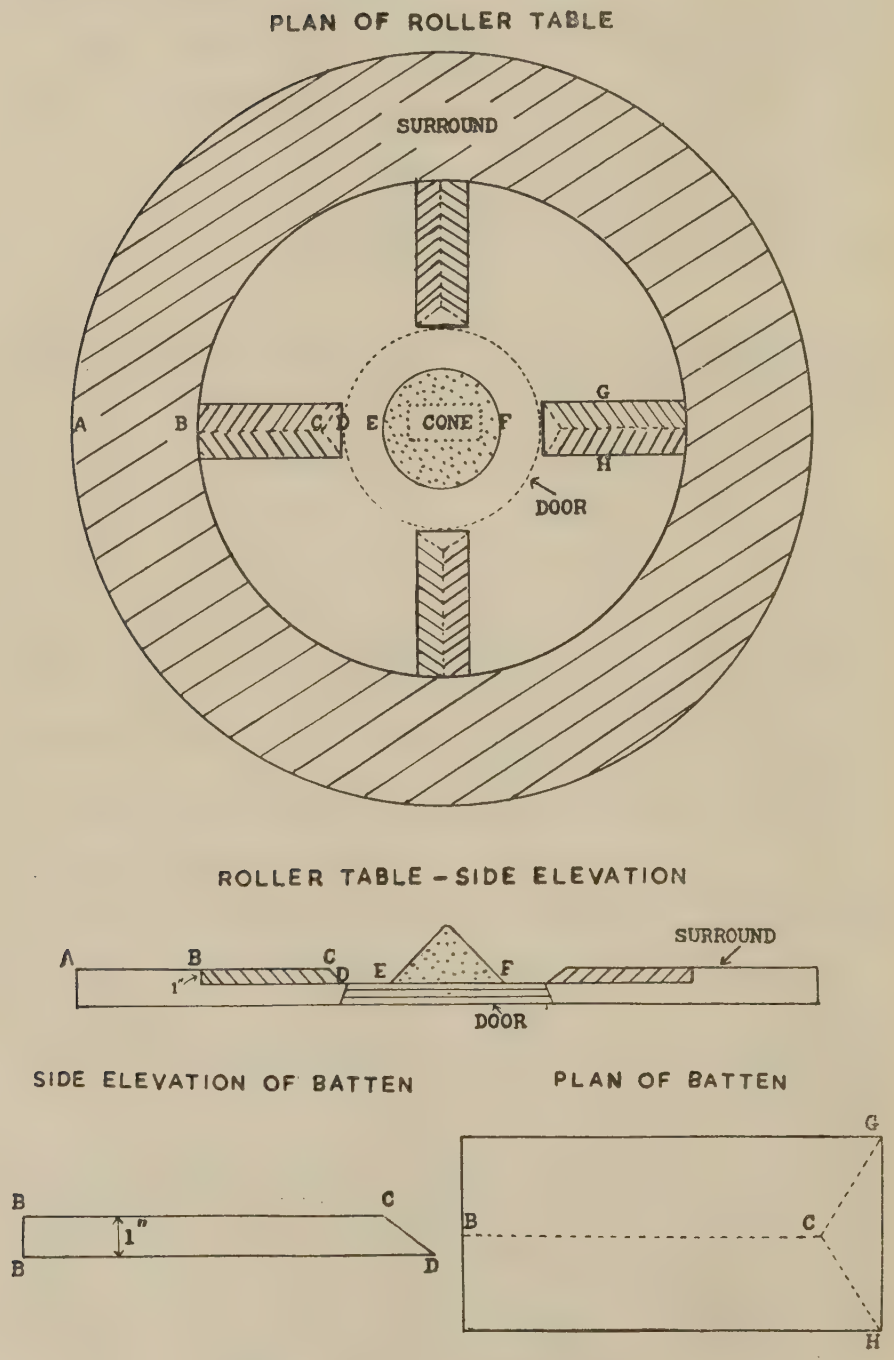

Figure 1. Sections of roller table and batten

TABLE 2.—*Dimensions of the Keegel battens for rollers of different sizes*
(*see Figure* 1)
(*all figures are given in inches*)

	32 Walkers	34 C.C.C.	34 David-sons	35 Walkers	36 Mar-shalls	40 C.C.C.	40 Walkers	44 C.C.C.	44 David-sons	45 Walkers	45.5 C.C.C.	46.5 Walkers	46.6 David-sons	47 C.C.C.
1. Crank throw	10	10	9	10	9	10	10	10	10	10	11	12	10	11
2. Diameter of table	66	63½	52¼	65	59½	69	70¼	73	64¼	75¼	73	75¼	67	73
3. Diameter of door (at table level)	15	17	18	18	18	23	20¼	26	20½	20¼	26	20¼	20½	26
4. **Keegel cone**—Base EF.	6½	7	8	8	9	10	10½	12	12	13	12	11½	13	12½
Height	3¼	3½	4	4	4½	5	5¼	6	6	6½	6	5¾	6½	6¼
5. Table surround AB	13	11¾	6	11½	9¾	11½	12½	12½	8	13	11	11	8½	10½
6. **Keegel battens**—Length of ridge BC	10¾	9¾	9¼	10¼	9¼	9¾	10¾	9¼	12	12¾	10¾	14¾	13	11¼
Length of bottom surface BD	12½	11½	11	12	11	11½	12½	11	13¾	14½	12½	16½	14¾	13
Width GH	5½	5½	5½	5½	5½	6	6	6	6	6	6	6	6	6
Depth	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Notes — 1. *The sides of the battens should be straight.*
2. *The base of the batten should be flush with the table. There should be no projecting edges.*
3. *The ridges of the battens and edge of the table surround should not be sharp.*
4. *The battens should be made of brass or gun metal. ~~Modern~~ Woolen battens wear off quickly and when they are wasted their performance is considerably impaired.*
5. *A gun-metal lining should be fixed at the position where each batten meets the surround about 1½" wide and 5½ - 6" in length (to correspond to the width of the batten).*

9. Stalk Extraction.—The C. C. C. Electrostatic Stalk Extractor (Standard model—Figure 2) underwent comprehensive tests, and gave satisfactory results.

According to the trials conducted at St. Coombs, the performance of the machine came up to the standard claimed by the makers. Notes on the operation of the machine are supplied by the Colombo Commercial Co. and these should be carefully followed.

In view of the wide variation of the content of stalk in teas from factory to factory, apart from the style and size of teas manufactured, no hard and fast rule can be given for the method of using the machine. However, the following observations may be of interest :—

9.1 Effect of charge.—The strength of the electric field is regulated by a selector switch from position 0 to 4, No. 4 indicating the strongest charge and '0' no charge. Effective separation of stalk can be brought about at any of the positions 0, 1, 2, 3 or 4 depending on the gap setting and the type of tea handled.

Generally speaking, optimum results are obtained with low charges and small gap settings. High charges result in too much good tea being included in the tailings (the stalky fraction).

9.2 Effect of rate of feed.—Very thin feeds, though resulting in almost complete removal of the stalk from the cleaned fraction, also give rise to the extraction of a large proportion of tea with the stalk. With very heavy feeds, stalk separation is not very effective.

9.3 Comparison of three methods of stalk extraction.—In treating a tea for the separation of stalk, three distinct methods are :

(*a*) stalk extraction in one operation ;

(*b*) obtaining the cleanest fraction possible, and re-treating the tailings to recover the tea they contain;

(*c*) obtaining only stalk in the tailings, and returning the cleaned fraction to the feed to remove the stalk it contains.

The single stage operation generally gives the best results. There is very little to choose between methods (*b*) and (*c*), though (*c*) may be considered slightly better, but this involves the handling of a larger amount of the original product.

The machine is therefore most economically used by taking the minimum amount of tailings with the least extraction of good tea. A little stalk in the cleaned fraction and a little tea in the tailings are inevitable. Though re-treatment may bring about a cleaner tea, quite a fair proportion of tea is then lost with the second tailings.

9.4 Effect of uniformity of material.—It is now generally recognized that the more uniform the size of particles of tea, the better the degree of separation. For this reason an unsifted dhool, however stalky it may be, is not such good material for electrostatic separation as the graded dhool. A preliminary sifting to separate the dhool into two well defined fractions—say one above No. 10 mesh and the other below it—and treating of each of these fractions separately gives better results. Cutting of the larger size fraction prior to passing through the electrostatic stalk extractor also improves the degree of separation. Big-bulk treated in a similar manner gives better results than uncut tea and also increases the throughput considerably.

FIGURE 2. The C. C. C. electrostatic stalk extractor (Standard model).

9.5 Effect of storage of tea overnight.—The separation of stalk from freshly fired teas does not appear to be very much better than from teas stored overnight, as is generally thought to be. The difference between the cleaned fractions is slight. Though slightly more stalk may be removed from hot teas, more black tea is also removed with the stalk than by treating them when cool.

However, in the case of teas which have been stored for a considerable period and have gained an excessive amount of moisture, final firing quite definitely improves the degree of separation.

9.6 Throughput of the machine.—It will be appreciated that capacity is dependent upon the stalk content of a tea and the required degree of separation of stalk; it is also governed by the size of the particles. The following figures given in Table 3, though serving as a guide to the performance of the C. C. C. Electrostatic Stalk Extractor, are really meant to show the relative 'throughputs' of various types of tea.

Table 3. *Throughput of the C. C. C. Electrostatic Stalk Extractor (St. Coombs teas)*

4th dhool—unsifted—			400	lb.	approx.	per	hour
,, ,, —above No. 10 mesh	—	—	200	,,	,,	,,	,,
,, ,, —below No. 10 mesh	—	—	800	,,	,,	,,	,,
Big-bulk	—	—	90	,,	,,	,,	,,
Big-bulk after cutting	—	—	350	,,	,,	,,	,,
Pekoes	—	—	700	,,	,,	,,	,,
Fannings	—	—	1000	,,	,,	,,	,,
Broken Mixed	—	—	700	,,	,,	,,	,,

10. Miscellaneous.—

10.1 Effect of dieldrin spraying on the made tea.—Though a considerable improvement of yield may result from dieldrin spraying, the liquors of the teas made do not appear to be affected in any way. These tests were conducted on leaf, approximately 18 months after spraying, on three successive pluckings.

10.2 Taint trials.—In three separate trials, at intervals of 2, 9 and 16 days after treatment of wood with "Rentokil" Q. D. (a timber preservative), leaf that had been in contact with the treated wood produced teas which were very badly tainted. Taint was still noticeable in a subsequent test carried out 6 weeks after application of the compound.

A curious feature is that the treated wood does not appear to have an odour. The chemical probably becomes effective in the presence of moisture. Wet leaf was used in these trials to test extreme conditions.

11. Acknowledgements.—We once again record our thanks and appreciation to the Tea Tasters in Colombo, who have continued to render valuable assistance in the tasting of our experimental teas.

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Printed by The Associated Newspapers of Ceylon, Ltd., Lake House, Colombo, for the Tea Research Institute of Ceylon, St. Coombs, Talawakele.

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It is particularly requested that letters should not be addressed to officers by name. Specimens and other consignments sent by rail should be forwarded to Talawakele Station, c/o Messrs M. Y. Hemachandra & Co. Ltd., Forwarding Agents. *Carriage should be pre-paid.*

Low-country estates should address their correspondence and enquiries to the Low-Country Adviser, T.R.I., Planters' Club, Ratnapura.

Visitors' Days.—The *second* and *last* Wednesdays in each month have been set aside for Visitors' Days at St. Coombs Estate and also at the T.R.I. Sub-Station, Gonakelle Estate, Passara, when it is hoped that those interested will visit the station.

Guest House.—The house formerly used for guests is now an officer's residence and it is regretted that, for the time being, no Guest House facilities are available. Those visiting the Institute or the Estate on business, who are unable to arrange accommodation in the neighbourhood, should seek the help of the Director.

Publications.—The Tea Quarterly, Bulletins (New Series), Pamphlets, and Annual Reports, published by the Tea Research Institute will be sent free of charge to Superintendents of Ceylon tea estates over ten acres in extent and to estate agencies dealing with Ceylon tea, if they register their names with the Director, Tea Research Institute of Ceylon, St. Coombs, Talawakele.

Other persons can obtain the publications of the Institute on application to the Director, the post-free subscription being fifteen rupees per annum for persons resident in Ceylon or India and £1-5-0 for those resident elsewhere. Single numbers of *The Tea Quarterly* can be obtained for Rs. 2-50 or 4*s*.

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